

GarageUpgrades! | OFF-ROAD TEST: 7 New Crossovers | Gas VS Electric Yard Tools

Popular Mechanics

SCIENCE TECHNOLOGY AUTOMOTIVE HOME ADVENTURE

POPULARMECHANICS.COM AUGUST 2011

SECRETS OF THE NAVY SEALS

The Weapons, Tactics and Training
of the World's Most
Elite Warriors

+
THE
BIN LADEN
RAID
STEP BY STEP

The HK416 is used by U.S. special-operations forces, including the Navy SEALs team that killed Osama bin Laden.

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Aug.



Heckler & Koch's 416 assault rifle was designed for use by U.S. special-ops forces.

50 Beyond bin Laden: The Navy SEALs' Next Missions The top-secret takedown of America's No. 1 terrorist target signaled a lethal new era in special-ops warfare. PM dissects the daring, innovative tactics the U.S. military uses to keep our enemies at bay. BY KALEE THOMPSON, SHARON WEINBERGER AND JOE PAPPALARDO

60 The Wrong Haul Inefficient commercial fishing kills millions of turtles, sharks and birds—and a lot of jobs too. Redesigning gear and new methods seek to limit the collateral damage. BY T. EDWARD NICKENS

64 10 Ways to Change the World (Starting in Your Own Backyard) It's DIY with a cause: A man builds bus shelters for school kids in Texas, a group of friends in Seattle starts a 220-member tool library . . . They're all part of an inspiring trend, showing that charity starts very close to home. BY AMANDA DEMATTO

68 Where the Pavement Ends Station wagons, minivans and SUVs have cleared the way for a new breed of family hauler: the roomy, AWD crossover. We test seven on the dunes of Lake Michigan. BY EZRA DYER

76 Turf Wars Can a cordless electric yard tool really stand up to a gas-powered model? Two grounds-maintenance masters attempt to settle the score in an epic head-to-head battle. BY EVAN ROTHMAN

On
the
cover

Tools of the Navy SEALs include the HK416 assault rifle, which was reportedly used to kill Osama bin Laden. Photograph by Eric Ogden, props by Tim Costa, gear worn by model Tim Ryan. (Active SEALs don't pose for photos, but their weapons do.)

PHOTOGRAPH BY ERIC OGDEN

Tech Watch

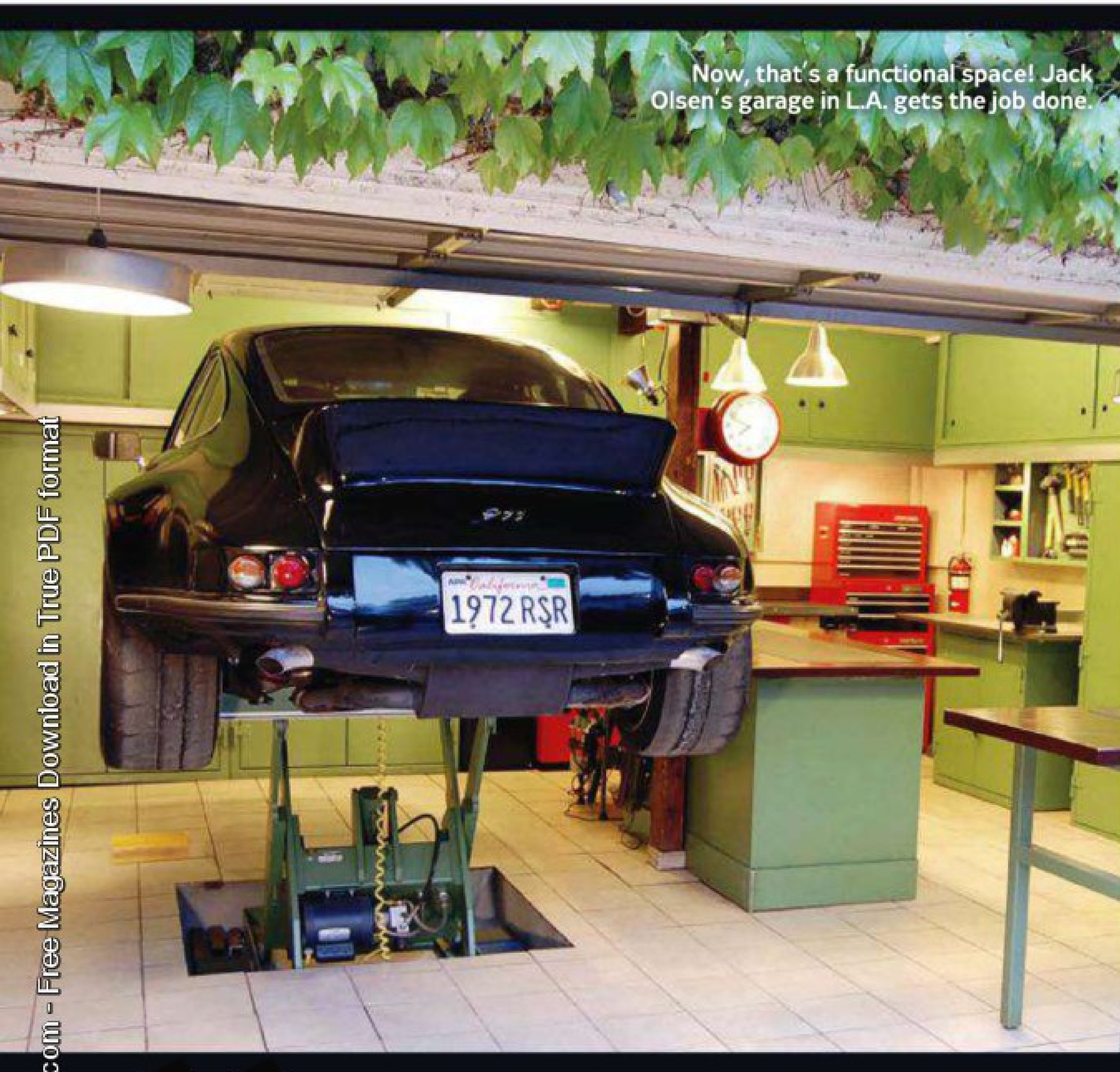
11 Check Your Head New tech allows radiologists to "print" a 3D model of a patient's skull. **Plus:** *The Lord of the Rings'* Andy Serkis on performance capturing and bringing fantasy characters to life; how cyber crooks turn your data into cash.

Upgrade

23 Quicker Gripper Vise-Grips without the pesky screw to adjust? Yep. C.H. Hanson's Automatic Locking Clamps put the squeeze on fast. **Plus:** The folly of the \$6000 toilet; editors pick the best tools of the year and test six new digital tablets.

New Cars

31 The One BMW introduces the M3's lighter, more agile little brother—the 1M. **Plus:** The New York International Auto Show; Honda Civic Hybrid versus Toyota Prius mileage road test.



Now, that's a functional space! Jack Olsen's garage in L.A. gets the job done.

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—DIY Home, "The Ultimate Garage," page 99

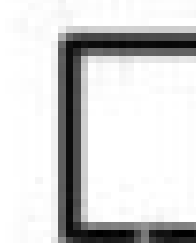
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44 Flight Risks Clues obtained from the wreckage of Air France Flight 447 spark serious questions about the safety of today's high-tech airplanes.

On
the
cover

50 Secrets of the Navy SEALs **68 7 New Crossovers**
76 Gas vs Electric Yard Tools **99 Garage Upgrades**

PopMech
diy



Tech

81 After the Crash You've backed up your computer files, right? Okay, good. Now, here's how to restore your data.

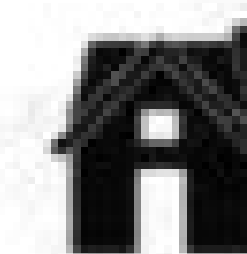
84 Digital Clinic Where have all the microprojectors gone? **Plus:** Banishing Flash cookies for good; how to write emails now that auto-send later.



Auto

89 Trailering Basics Hitch 'er up! We explain how to prep, load and hook up your trailer for maximum road safety.

94 Car Clinic The real danger of an oily-rag fire in the shop. **Plus:** The steps to loosening a stuck battery bolt; the final word on the water-powered-car myth.



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99 The Ultimate Garage How to make the most of your man-space, whether it's a workshop, storage spot or hangout.

104 Homeowners Clinic PM's plans for the superstrong, hold-anything shelf. **Plus:** Lighten up! Restocking your box with tools that weigh less.

110 PM Saturday Dang squirrels—always raiding the bird feeder. Give the critters the runaround with our spinning-tightrope solution.



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CONFESSIONS OF A CAR SALESMAN An insider
tells us what's really happening when a car
salesperson leaves to talk to the manager, why
dealerships don't care about all-cash offers, the
best times to buy a car and why it's harder than
ever to gouge a customer—car buyers come to
the lot with more savvy than ever before, and
salespeople can't afford to get bad reviews.
popularmechanics.com/carsalesman



BIGGEST AUTO FLOPS The 10 cars that most
deserved to die, including flops like the DeLorean
DMC-12 (above), Ford Pinto and Pontiac Aztek.
Let us know what models you'd add to the list.
popularmechanics.com/autoflops

SUMMER STICKER SHOCK The economic effects of
Japan's earthquake–tsunami disaster are spread-
ing through the auto industry's supply chain. That
could mean you'll be paying more if you buy a new
car this summer.
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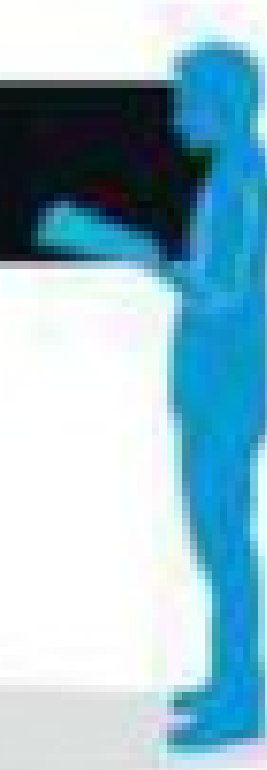
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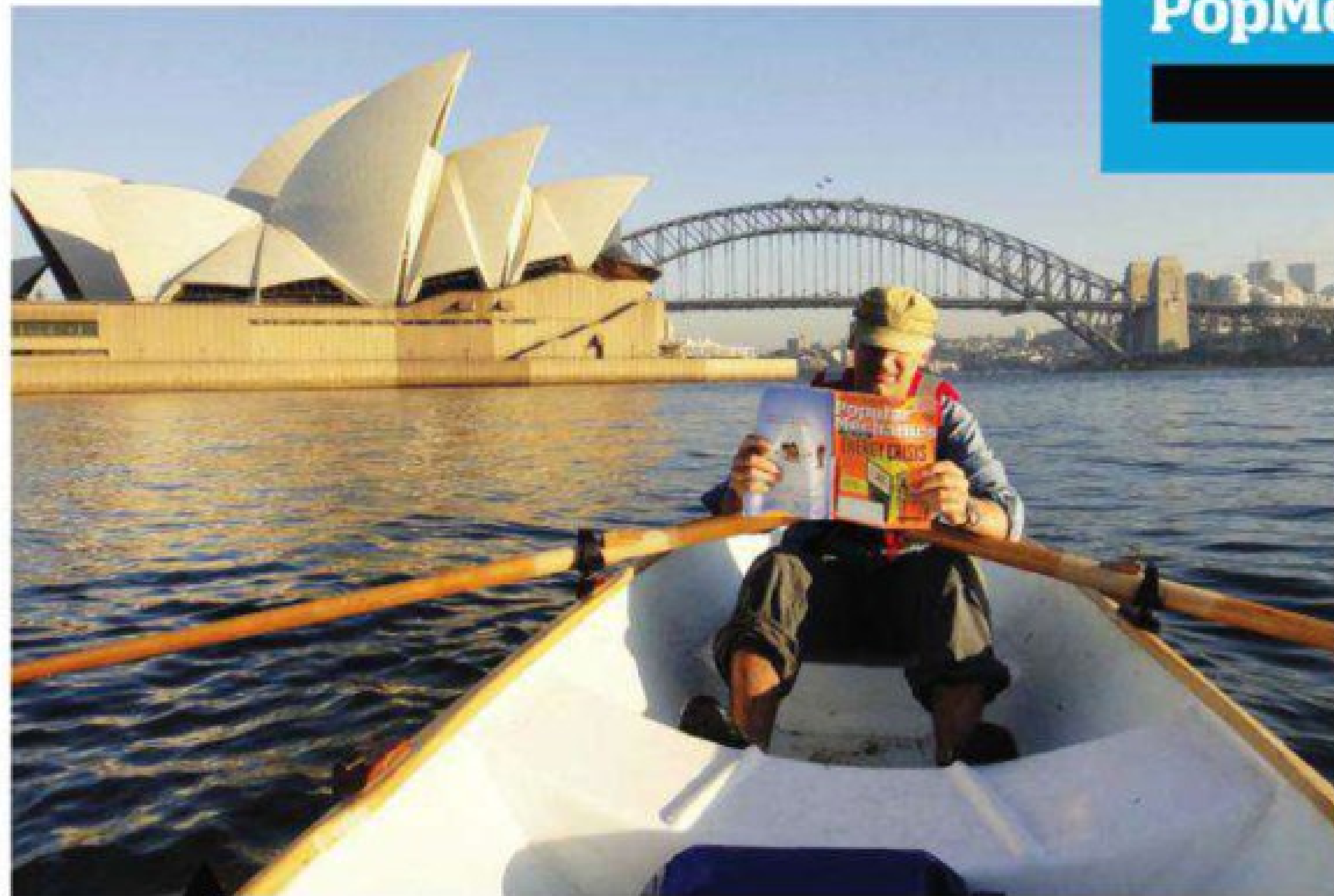
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PM LETTERS

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G'day, mate! Longtime PM reader Peter Miller, of Sydney, knows a good thing when he sees it. Never mind the sublime beauty of the Sydney Opera House and Harbour Bridge—Miller focuses on the pages of PM while enjoying a sunny day from a seat in his dory. "There's nothing better than sitting back and finding out how the future will look," he says.

what abrupt termination—on NASA. I'm not saying the agency couldn't have been more efficient (it could've), but the shuttle has been a valuable, innovative resource for our country. I believe cutting NASA programs is a mistake. Let's keep NASA strong.

GEORGE KETOLA LOCKE, NY

Blast From the Past

I found your story about getting 40 mpg with nonhybrid gas-powered cars ("High-Mileage Test," June) very frustrating. I've been getting worse mileage with every new car I've owned for the past three decades. My '83 Honda CRX was small, but it drove like a bat out of hell and got 46 mpg. Every car I've bought since has gotten worse mileage. If you want 40 mpg, I say, buy an '80s import. KEVIN LENAGH FAIRDALE, ND

A Better, Brighter Power Plan

Rarely does an article make me want to stand up, throw a fist in the air and say, "Hell, yeah!" But that was my reaction to "The New Energy Crisis: 10 Fixes" (June). It lined up real-world solutions to our power problems. If Congress would get its hands out of lobbyists' pockets, the U.S. could be a world energy leader. In the meantime, our policies make us look like we're stumbling around in the dark.

HIROYOSHI MURASAKI MIAMI

If I thought they would read it, think about it and understand it, I would buy a copy of your "Energy Crisis" issue for every member of Congress. POPULAR MECHANICS has come up with so many ways to boost America's energy supply. And what has Congress accomplished? Not much. Thanks for always teaching me something new. STEVE CORSON ROCKPORT, ME

A Program Worth Keeping

I was shocked to see Jim Meigs's column "Was the Shuttle Worth It?" (June) place so much of the blame for the shuttle program's failures—and some-

EDITOR'S NOTE: For a variety of reasons—mostly customer demand and tougher crash and emissions regulations—cars are roughly 40 percent heavier than they were three decades ago. The weight gain may be a touch excessive, but it's not without benefits. Today's cars are far more roomy, refined, feature-laden, clean and safe. The challenge for automakers is to increase fuel economy while retaining these attributes. You may yearn for a Geo Metro, but we think that puts you in a small minority.

LARRY WEBSTER AUTOMOTIVE EDITOR, POPULAR MECHANICS

From our fans
and followers



Hello, PM readers on Facebook and Twitter—and thank you for commenting on our stories! Here is some recent feedback:

Oh, Mommy! How I'd like to take a Test Drive . . .

@DEANPETERS, VIA TWITTER
("2012 Lamborghini Aventador LP 700-4 Test Drive," popularmechanics.com)

On Facebook, we asked what you would add to our list of Top 10 Cars That Deserved to Die. Here's what you said:

Cadillac Escalade and the big

Humvee models. There's no excuse for those gas-guzzling Suburban wannabes.

ELIZABETH R. APGAR TRIANO, VIA FACEBOOK

Any and all electric cars. Gas and diesel is the only way to go!

JACK WALTERS, VIA FACEBOOK

The Ford Pinto.
TRACY CULLEN, VIA FACEBOOK

I was given a Chevy Chevette as a company car once. It was a real stinker. The steering wheel wasn't even centered.

HAROLD MCMICKLE, VIA FACEBOOK

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do you
think?

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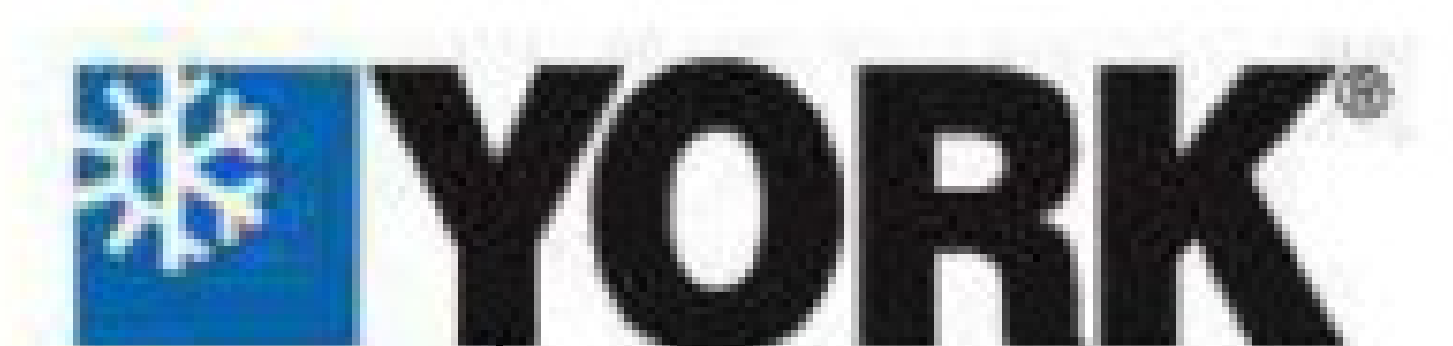
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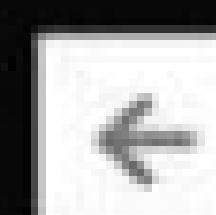


It's time to get comfortable.

Check Your Head



⇒ When neurosurgeons plan brain surgery, it helps to be able to visualize the problem. Radiologists at the Tripler Army Medical Center in Hawaii can now create quick, inexpensive 3D models of a patient's skull. A 3D printer, a tool used by architects to create building models, uses inkjet technology to "print" layer by layer the high-resolution data collected by a CT scanner. The printer, made by Z Corporation, also allows surgeons to design perfect-fitting replacement pieces of medical-grade plastic for damaged skulls. — ALEX HUTCHINSON



TechWatch

QUICK HITS



WATER-HARVESTING MESH

➡ Many villagers in the deserts of Africa and India walk for hours each day to collect water, yet one-third of the planet's fresh water is floating in the atmos-

phere rather than pooling in rivers and lakes. MIT engineers, inspired by the bumpy surface of a Namib Desert beetle that collects moisture from the air, have developed a mesh to harvest water from fog.

The team refined a decades-old concept to find the optimal balance of water-attracting and -repelling surfaces on the mesh so that droplets coalesce and drip into a container. One square yard of the prototype material can produce about 1 quart of water a day.



SELF-HEALING PLASTIC

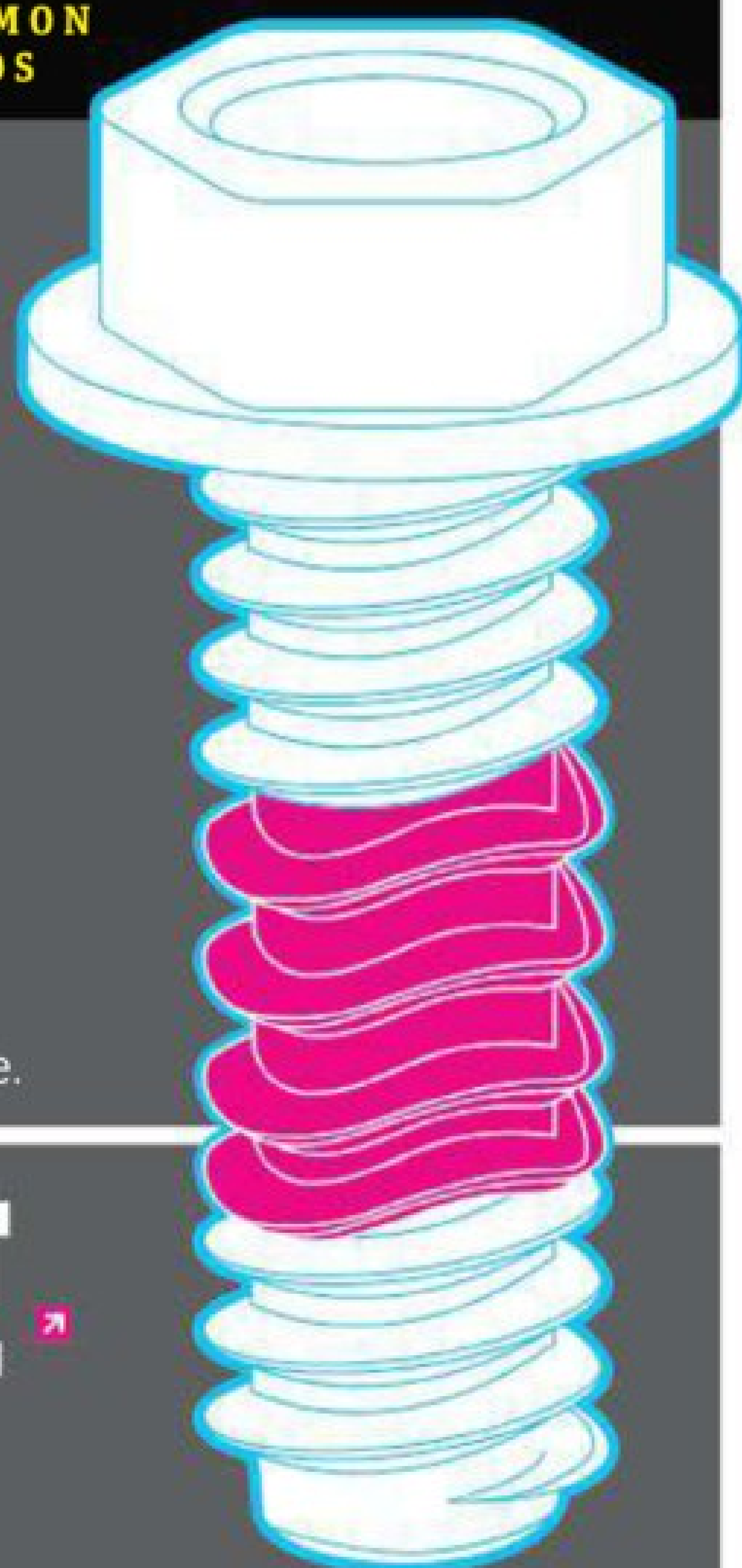
➡ In a leap forward for macromolecular engineering, researchers have developed a polymer that heals itself under ultraviolet light. The substance, developed by scientists at Case Western Reserve, the Army Research Lab and a Swiss

university, is made of molecules bonded with metal ions that act like glue. Intense UV light undoes the bond, allowing the polymer coating to flow like a liquid into cracks and scratches. The film resolidifies without light.

UNCOMMON THREADS

Twisted

Machine screws are great—when they stay put. Engineers at Illinois Tool Works' Shakeproof division have developed a thread that prevents screws from vibrating loose.



WITH A PORTION OF THE THREAD SHAPED LIKE A SINE WAVE, THE NEW SCREWS GENERATE PREVAILING TORQUE THAT LOCKS THEM INTO PLACE.

IN THEIR OWN WORDS

“Every drop in the ocean has tens of thousands of microbes that are changing the chemistry around them. They are everywhere, and we know almost nothing about them.”

JAMES BELLINGHAM

Chief technologist, Monterey Bay Aquarium Research Institute



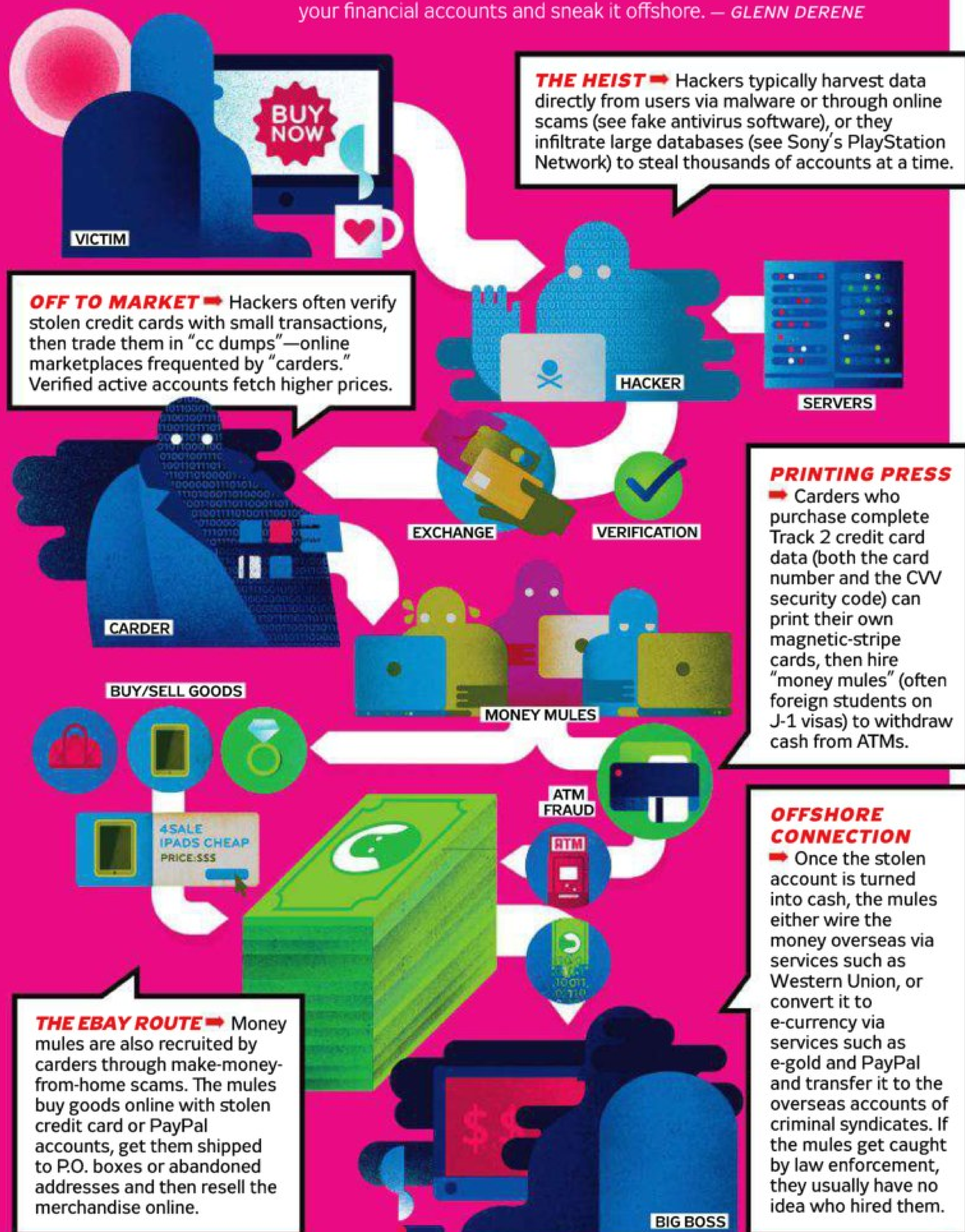
LASER IGNITION

➡ Japanese researchers are working with a Toyota subsidiary to replace the spark plug with a multibeam laser igniter. Lasers can generate enough energy to ignite cleaner-burning fuel mixtures in just nanoseconds, improving fuel efficiency. The new igniter produces a two-beam laser less than ½ inch long and fits neatly under the hood.

UNDERGROUND ECONOMY

How Cyber Crooks Turn Your Data Into Cash

The massive data breach of Sony's PlayStation Network in April took down the service for 23 days, compromised the accounts of more than 100 million users and exposed 12.3 million credit cards to hackers. But what, exactly, happens to credit card and financial accounts once they enter the cyber-crime underworld? We asked Austin Berglas, cyber division coordinator at the FBI, and Dean De Beer, chief technology officer of security firm ThreatGRID, to guide us through the process by which criminals steal money from your financial accounts and sneak it offshore. — GLENN DERENE



EXTREME ASTRONOMY



Backward Planets

→ Astrophysicists at Northwestern University have solved the mystery of why some planets orbit their stars the "wrong" way—circling in one direction while the central star and other planets in the system rotate the opposite way. The phenomenon is an apparent contradiction to theories about how planets form. But a simulation has now shown that gravitational forces from a large, distant planet can eventually shift the orbits of "hot Jupiter" planets located close to their stars. The steady transfer of angular momentum—an object's tendency to spin—can narrow the inner planet's orbit and ultimately flip its direction.

—A.H.



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INSECT MIMICRY

Ballistic Bug Bot → A robot that can move like a caterpillar sounds more sluggish than useful. But some caterpillars use a trick called ballistic rolling to escape predators: They thrust their bodies into the shape of a wheel and roll away at startlingly high speeds. The GoQBot, built at Tufts University, does the same thing, springing into circular shape in less than 100 milliseconds. The future benefit: In caterpillar form, GoQBot can wriggle into debris to search for survivors in disaster areas—but it can get there much more quickly than conventional limbless bots, by wheeling across open ground. — A.H.



The soft-bodied GoQBot is named for the shape it makes when it curls up to roll away. ▲

EVERYDAY PHYSICS

Balancing Act

EVERYONE KNOWS THAT BIKES IN MOTION BRIEFLY STAY UPRIGHT WITHOUT A RIDER. NOW SCIENTISTS FINALLY UNDERSTAND WHY.
— ALYSON SHEPPARD

The bike's wheels are small to minimize gyroscopic torque. It's further canceled by an upper set of wheels rotating in the opposite direction.

STEERING
AXIS

The forward wheel sits in front of the steering axis, so it cannot follow, or "trail," the bike as it changes directions—eliminating the caster effect.

REAR
WHEEL

FRONT
WHEEL

It's a familiar phenomenon: Push a riderless bicycle forward fast enough and it will briefly stay upright. An international team of researchers now says the established explanations of why the bike doesn't immediately topple are misleading.

Scientists have attributed a bike's tendency to right itself to two effects. The first is gyroscopic torque, which steers the spinning front wheel in the direction of the fall when the bike leans. This brings the wheels back under the bike's center of mass, keeping it upright. The second, the caster effect, dictates that the front wheel align to the direction of travel.

But researchers in the U.S. and the Netherlands built a

bike that doesn't exhibit either effect, yet still self-balances (left). The engineers determined that the distribution of mass—low in front and high in back—is actually what contributes to keeping the bike upright. After a riderless bike is pushed, the front dips faster, causing the front wheel to steer into the fall and briefly stay upright. The test bike is not built to ride, but researchers are hoping manufacturers use the study's findings to design folding or recumbent bikes that are easier to balance.

Andy Ruina, a mechanical engineering professor at Cornell University and co-creator of the bike, notes that the discovery could also aid makers of walking bipedal robots, which rebalance every time they take a step. "Steering right on a bike is almost mechanically identical to stepping right when you're walking," he says.



TUSHKA, OK
04.14.11



GLOUCESTER COUNTY, VA
04.17.11



COLERAIN, NC
04.18.11

TIMELINE

- high wind
- large hail
- tornado
- warm front
- cold front
- dry line

The Perfect Storm

Violent twisters made 2011 the seventh-deadliest tornado year in history, so far—and April was one of the most destructive months on record. Fueled by a massive, multistate storm system, at least 150 of April's more than 500 tornadoes happened during just a few days, starting on April 14. Here's how they unfolded.

BY ELIZABETH SVOBODA

APRIL 14 SOUTHERN KANSAS AND EASTERN OKLAHOMA

Moist air from the Gulf of Mexico saturates the region as a lid of hot, dry air moves in from the high-elevation Mexican mainland. That cap erodes as temperatures climb during the day. "It's like boiling water in a pot," says Victor Gensini, a climatologist at the University of Georgia. "Take the lid off and the air explodes upward due to differences in density." The air condenses as it rises, causing heavy rain.

APRIL 15 ILLINOIS, MISSOURI, LOUISIANA, ALABAMA AND MISSISSIPPI

The sandwich of hot and moist air meets the high-altitude jet stream as a cold front begins to move through the area, blowing the warmer lid off. The jet stream fuels wind shear, winds that change direction and speed with altitude. Multiple tornadoes result as the wind shear turns surrounding turbulent air masses like a corkscrew, creating rotating funnels.

APRIL 15 ACROSS THE SOUTH AND MIDWEST

As a supercell thunderstorm passes, people report unusually large hailstones, some the size of baseballs. Hail forms when raindrops in the upper reaches of thunderheads freeze together, accumulating layers of ice from the moist clouds. This storm's thermal layers cause exceptionally strong updrafts: The stronger the updraft, the larger the hail can become before it grows too heavy and falls out of the sky.

APRIL 16 VIRGINIA, NORTH CAROLINA AND SOUTH CAROLINA

Having migrated to the East Coast, the storm system prepares for its final hurrah. It gets an extra boost from a warm front pushing in from the south, which fuels continued instability between warm, moist air masses below and hot, dry air above. Jet stream activity remains strong, creating rotating wind shear that spins the turbulent air into dozens of additional tornadoes.

APRIL 17 ATLANTIC OCEAN

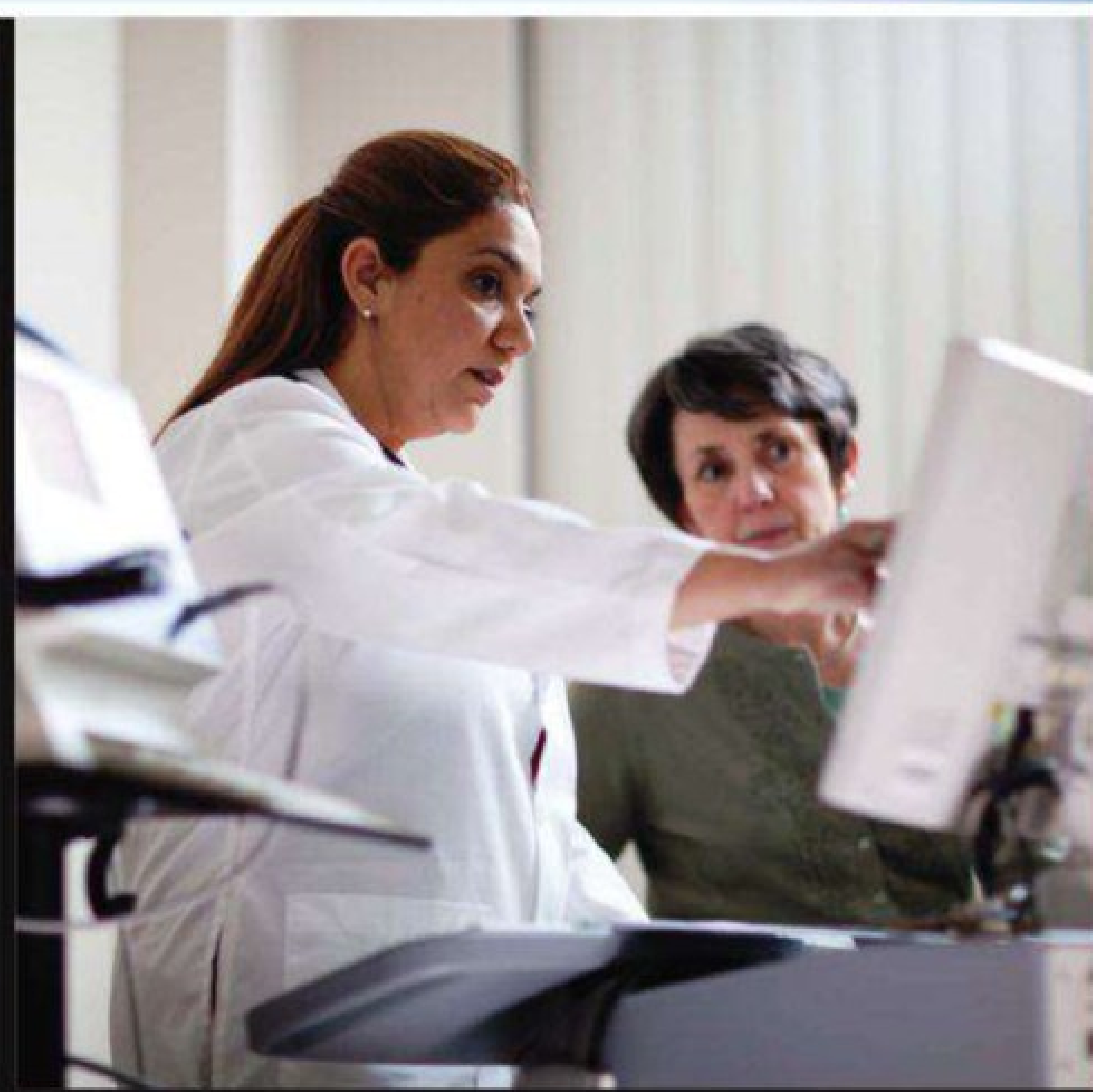
The damaging megastorm finally pushes off into the Atlantic Ocean and begins to diminish. Without hot, dry air flowing in from the Mexican plateau to create the lid that maintained the storm's intensity, the system finally dissipates. "April 2011 is going to be the case study everyone looks at," Gensini says. "It's anomalous, absolutely phenomenal."

"FINALLY I can offer my patients a choice."



Dr. Minerva Santo-Tomas
Cardiologist
Miami, FL

Doctor Compensated



If you need help paying for your medication **CARES** *can help,*
FOUNDATION
and for more information about PRADAXA call 1-877-PRADAXA or visit pradaxa.com.



If you have an irregular heartbeat called *atrial fibrillation*

not caused by a heart valve problem

ask your doctor about **PRADAXA.**

- In a clinical trial, PRADAXA 150 mg **reduced stroke risk 35% more** than warfarin. Risk reduction was greatest when compared to patients on warfarin whose blood tests showed lower levels of control.
- **No regular blood tests**

PRADAXA is a prescription blood-thinning medicine used to reduce the risk of stroke and blood clots in people with atrial fibrillation not caused by a heart valve problem. With atrial fibrillation, part of the heart does not beat the way it should. This can cause blood clots to form, increasing your risk of a stroke. PRADAXA lowers the chance of blood clots forming in your body.

IMPORTANT SAFETY INFORMATION ABOUT PRADAXA

PRADAXA can cause bleeding which can be serious and sometimes lead to death. Don't take PRADAXA if you currently have abnormal bleeding or if you have ever had an allergic reaction to it. **Your risk of bleeding with PRADAXA may be higher if you:** are 75 years old or older, have kidney problems, have stomach or intestine bleeding that is recent or keeps coming back or you have a stomach ulcer, take other medicines that increase your risk of bleeding, like aspirin products, non-steroidal anti-inflammatory drugs (NSAIDs) and blood thinners.

Call your doctor or seek immediate medical care if you have any of the following signs or symptoms of bleeding: any unexpected, severe, or uncontrollable bleeding; or bleeding that lasts a long time, unusual or unexpected bruising,

coughing up or vomiting blood; or vomit that looks like coffee grounds, pink or brown urine; red or black stools (looks like tar), unexpected pain, swelling, or joint pain, headaches and feeling dizzy or weak.

It is important to tell your doctor about all medicines, vitamins and supplements you take. Some of your other medicines may affect the way PRADAXA works.

Take PRADAXA exactly as prescribed by your doctor. Don't stop taking PRADAXA without talking to your doctor as your risk of stroke may increase.

Tell your doctor if you are planning to have **any** surgery, or medical or dental procedure, because you may have to stop taking PRADAXA for a short time. PRADAXA can cause indigestion, stomach upset or burning, and stomach pain.

You are encouraged to report negative side effects of prescription drugs to the FDA.

Visit www.fda/medwatch or call 1-800-FDA-1088.

Please see more detailed Medication Guide on next page.

Reduce your risk of a stroke caused by a clot that starts in the heart.

Pradaxa[®]
dabigatran etexilate
CAPSULES

Read this Medication Guide before you start taking PRADAXA and each time you get a refill. There may be new information. This Medication Guide does not take the place of talking with your doctor about your medical condition or your treatment.

What is the most important information I should know about PRADAXA?

- PRADAXA can cause bleeding which can be serious, and sometimes lead to death. This is because PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.
- **You may have a higher risk of bleeding if you take PRADAXA and:**
 - Are over 75 years old
 - Have kidney problems
 - Have stomach or intestine bleeding that is recent or keeps coming back, or you have a stomach ulcer
 - Take other medicines that increase your risk of bleeding, including:
 - aspirin or aspirin containing products
 - long-term (chronic) use of non-steroidal anti-inflammatory drugs (NSAIDs)
 - warfarin sodium (Coumadin[®], Jantoven[®])
 - a medicine that contains heparin
 - clopidogrel (Plavix[®])
 - prasugrel (Effient[®])

Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.

- PRADAXA can increase your risk of bleeding because it lessens the ability of your blood to clot. While you take PRADAXA:
 - You may bruise more easily
 - It may take longer for any bleeding to stop

Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding:

- Unexpected bleeding or bleeding that lasts a long time, such as:
 - unusual bleeding from the gums
 - nose bleeds that happen often
 - menstrual bleeding or vaginal bleeding that is heavier than normal
- Bleeding that is severe or you cannot control
- Pink or brown urine
- Red or black stools (looks like tar)
- Bruises that happen without a known cause or get larger
- Cough up blood or blood clots
- Vomit blood or your vomit looks like "coffee grounds"
- Unexpected pain, swelling, or joint pain
- Headaches, feeling dizzy or weak

Take PRADAXA exactly as prescribed. Do not stop taking PRADAXA without first talking to the doctor who prescribes it for you. Stopping PRADAXA may increase your risk of a stroke.

PRADAXA may need to be stopped, if possible, for one or more days before any surgery, or medical or dental procedure. If you need to stop taking PRADAXA for **any reason**, talk to the doctor who prescribed PRADAXA for you to find out when you should stop taking it. Your doctor will tell you when to start taking PRADAXA again after your surgery or procedure.

See "What are the possible side effects of PRADAXA?" for more information about side effects.

What is PRADAXA?

PRADAXA is a prescription medicine used to reduce the risk of stroke and blood clots in people who have a medical condition called atrial fibrillation. With atrial fibrillation, part of the heart does not beat the way it should. This can lead to blood clots forming and increase your risk of a stroke. PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.

It is not known if PRADAXA is safe and works in children.

Who should not take PRADAXA?

Do not take PRADAXA if you:

- Currently have certain types of abnormal bleeding. Talk to your doctor, before taking PRADAXA if you currently have unusual bleeding.
- Have had a serious allergic reaction to PRADAXA. Ask your doctor if you are not sure.

What should I tell my doctor before taking PRADAXA?

Before you take PRADAXA, tell your doctor if you:

- Have kidney problems
- Have ever had bleeding problems
- Have ever had stomach ulcers
- Have any other medical condition
- Are pregnant or plan to become pregnant. It is not known if PRADAXA will harm your unborn baby.
- Are breastfeeding or plan to breastfeed. It is not known if PRADAXA passes into your breast milk.

Tell all of your doctors and dentists that you are taking PRADAXA. They should talk to the doctor who prescribed PRADAXA for you, before you have **any** surgery, or medical or dental procedure.

Tell your doctor about all the medicines you take, including prescription and non-prescription medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way PRADAXA works. Certain medicines may increase your risk of bleeding. See "What is the most important information I should know about PRADAXA?"

Especially tell your doctor if you take:

- rifampin (Rifater, Rifamate, Rimactane, Rifadin)

Know the medicines you take. Keep a list of them and show it to your doctor and pharmacist when you get a new medicine.

How should I take PRADAXA?

- **Take PRADAXA exactly as prescribed by your doctor.**
- Do not take PRADAXA more often than your doctor tells you to.
- You can take PRADAXA with or without food.
- Swallow PRADAXA capsules whole. Do not break, chew, or empty the pellets from the capsule.
- If you miss a dose of PRADAXA, take it as soon as you remember. If your next dose is less than 6 hours away, skip the missed dose. Do not take two doses of PRADAXA at the same time.
- Your doctor will decide how long you should take PRADAXA. **Do not stop taking PRADAXA without first talking with your doctor. Stopping PRADAXA may increase your risk of stroke.**
- Do not run out of PRADAXA. Refill your prescription before you run out. If you plan to have surgery, or a medical or a dental procedure, tell your doctor and dentist that you are taking PRADAXA. You may have to stop taking PRADAXA for a short time. See "What is the most important information I should know about PRADAXA?"
- If you take too much PRADAXA, go to the nearest hospital emergency room or call your doctor or the Poison Control Center right away.

What are the possible side effects of PRADAXA?

PRADAXA can cause serious side effects.

- See "What is the most important information I should know about PRADAXA?"
- Allergic Reactions. In some people, PRADAXA can cause symptoms of an allergic reaction, including hives, rash, and itching. Tell your doctor or get medical help right away if you get any of the following symptoms of a serious allergic reaction with PRADAXA:
 - chest pain or chest tightness
 - swelling of your face or tongue
 - trouble breathing or wheezing
 - feeling dizzy or faint

Common side effects of PRADAXA include:

- indigestion, upset stomach, or burning
- stomach pain

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of PRADAXA. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

How should I store PRADAXA?

- Store PRADAXA at room temperature between 59°F to 86°F (15°C to 30°C). After opening the bottle, use PRADAXA within 30 days. Safely throw away any unused PRADAXA after 30 days.
- Store PRADAXA in the original package to keep it dry. Keep the bottle tightly closed.

Keep PRADAXA and all medicines out of the reach of children.

General information about PRADAXA

Medicines are sometimes prescribed for purposes other than those listed in a Medication Guide. Do not use PRADAXA for a condition for which it was not prescribed. Do not give your PRADAXA to other people, even if they have the same symptoms. It may harm them.

This Medication Guide summarizes the most important information about PRADAXA. If you would like more information, talk with your doctor. You can ask your pharmacist or doctor for information about PRADAXA that is written for health professionals.

For more information, go to www.PRADAXA.com or call 1-800-542-6257 or (TTY) 1-800-459-9906.

What are the ingredients in PRADAXA?

Active ingredient: dabigatran etexilate mesylate

Inactive ingredients: acacia, dimethicone, hypromellose, hydroxypropyl cellulose, talc, and tartaric acid. The capsule shell is composed of carrageenan, FD&C Blue No. 2, FD&C Yellow No. 6, hypromellose, potassium chloride, titanium dioxide, and black edible ink.

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Ridgefield, CT 06877 USA



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Issued March 2011

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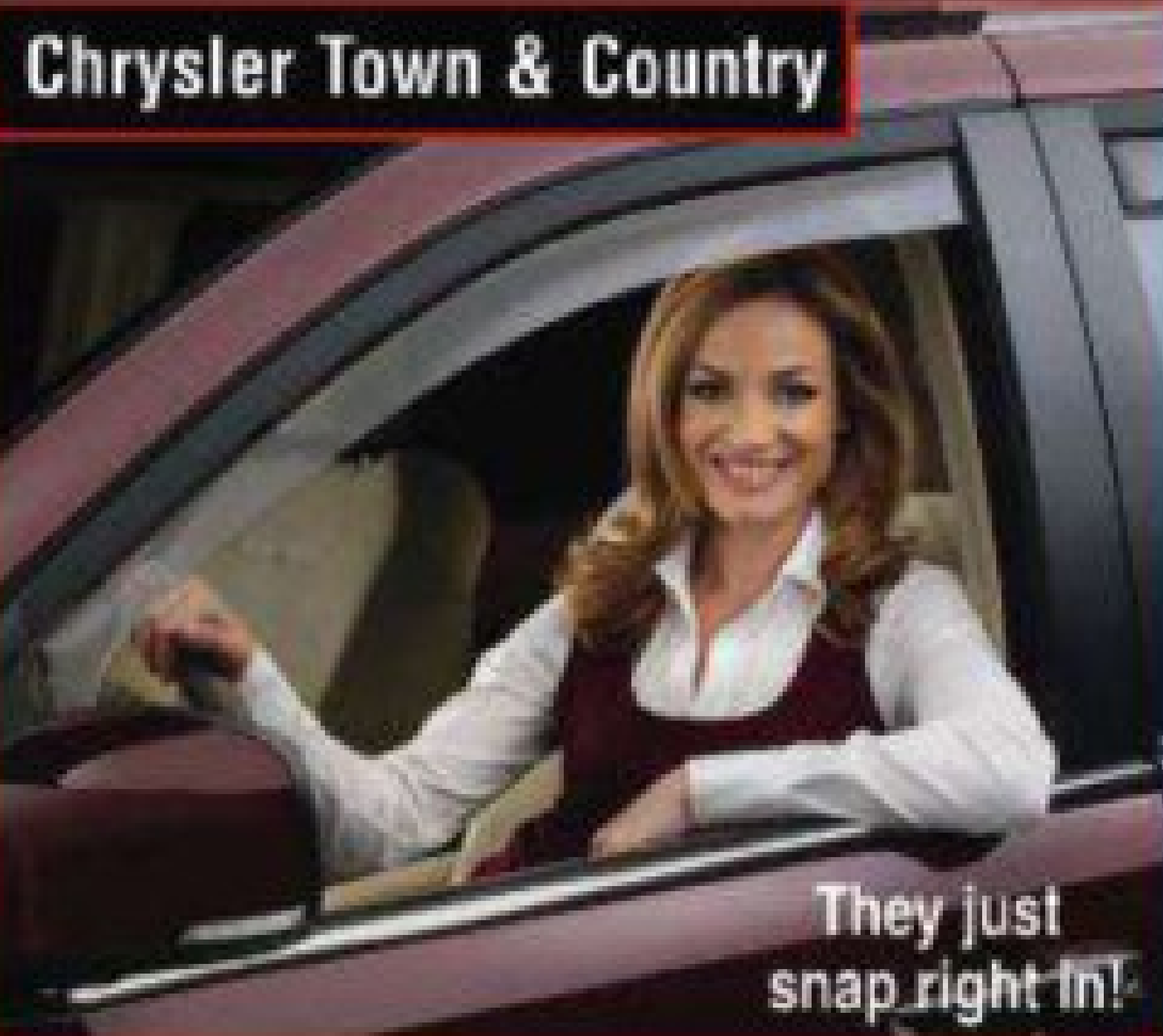
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TECH CULTURE

Mirror Image

What if you could meet yourself? In *Another Earth*, out July 20, scientists discover a second Earth—everyone who lives here also exists there. Star Brit Marling and director Mike Cahill wrote the film; the sci-fi elements were inspired by Richard Berendzen's *Pulp Physics* tapes. Cahill interviewed Berendzen, director of NASA's D.C. Space Grant Consortium, to gather information for the script. Later, the recorded interviews became the film's narration. "Mike threw himself into the research," Marling says. "He found scientific justifications for everything: The other Earth was on the opposite side of the



sun, so we didn't see it, and the alignment of the planets drew it out." Still, Berendzen says, the film is far from fact. "Another Earth would cause disruptions in the solar system and the tides," he says. "But the movie isn't about that other Earth. It's about a girl. It's less about science and more about philosophy."

—ERIN MCCARTHY



«ACTOR AS APE»

To play Caesar in the *Planet of the Apes* prequel, Andy Serkis wore performance-capture gear. VFX artists used the data to turn the actor into a photo-real chimp.

Method Aping

Andy Serkis on performance capture—using an actor's movement and expressions to create a digital character—from *The Lord of the Rings* to *Rise of the Planet of the Apes*, out Aug. 5.

You played Gollum, the first photorealistic movie character created using performance capture, in *The Lord of the Rings* [2001]. What was the process? We shot two passes of each scene: one with me in it and one with the other actors playing to an empty space. That gave us the option of rotoscoping, or painting, Gollum over my performance, or later using motion capture. That was a different shoot, in a small volume [sound stage], with just a few mo-cap cameras. The animators put the film shots of me next to a model of Gollum's face and matched it to every expression.

Did the technology evolve between *Rings* and *King Kong* [2005]? It was a

breakthrough for facial [performance] capture. After we wrapped principal photography, I had a two-month capture session. We did Kong's movements on a larger volume with more cameras, and I had 132 3D markers on my face to track my expressions.

To play Caesar in *Apes*, you used the helmet rigs created for *Avatar* [2009]. How did they change the filmmaking process?

Performance capture went from a peripheral activity to the fundamental way a film is shot. Before, we could only film in small volumes. But with facial markers painted on, and using helmets with cameras on a boom recording the face, the entire crew [plus] big set elements [can fit on]

the motion-capture stage, and actors can go anywhere.

On *Apes*, you did performance capture on live-action sets and outdoors. What made that possible?

In the volume, we used optical markers, and outside, we wore suits with LED markers. We changed how fast the LEDs pulse according to the lighting on set [and the cameras were synced to the LED frequency]. We shot on a 400-foot outdoor set, in full daylight, with shiny surfaces, which could have interfered with the performance-capture cameras' ability to receive information from the markers on our suits. But [the LEDs] worked really well.

You've used performance capture as an actor and as a director of video games like *Heavenly Sword* [2007]. What's next for this tech?

We're at the beginning of what performance capture has to offer. It allows actors to play characters that couldn't be created with makeup. I do think that in 3D gaming and 3D film, it's got a great future. —E.M.

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brand of paint in the U.S.**

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*KILZ brand received the highest numerical Equity Score, Trust Score and Quality Score among Paint Coatings included in the 2011 Harris Poll EquiTrend® Study. Please go to www.kilz.com for further details.

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Upgrade

Quicker Gripper

Metalworkers at Brooklyn, N.Y.'s Caliper Studio use 11-inch locking C-clamps to bend steel for a weld or grip irons to a jig. Adjusting the pressure-setting screw on a traditional clamp takes time, but **C.H. Hanson's Automatic Locking Clamps (\$25)** present a swift solution. The tools measure material in a 3½-inch throat, then automatically adjust to grip thick or thin objects with equal pressure. When Caliper's Mike Conlon saw a pair, he clamped any object in sight—a tabletop, a ⅝-inch steel bar, an I-beam—without a single adjustment. The shop crew stopped grinding for a moment to eye the tools with envy. — HARRY SAWYERS



UPGRADE



2011

EDITOR'S CHOICE
AWARDSBY HARRY SAWYERS
AND ROY BERENDSOHN

Leatherman Light → Proving that a low price doesn't compromise quality, the *Leatherman Sidekick* (\$40) artfully blends a few of our favorite tools: needle-nose pliers, a wire cutter and stripper, knife blades, a saw, a metal file and the all-important bottle opener. A total of 15 tools: That's a lot of hardware for 40 bucks.

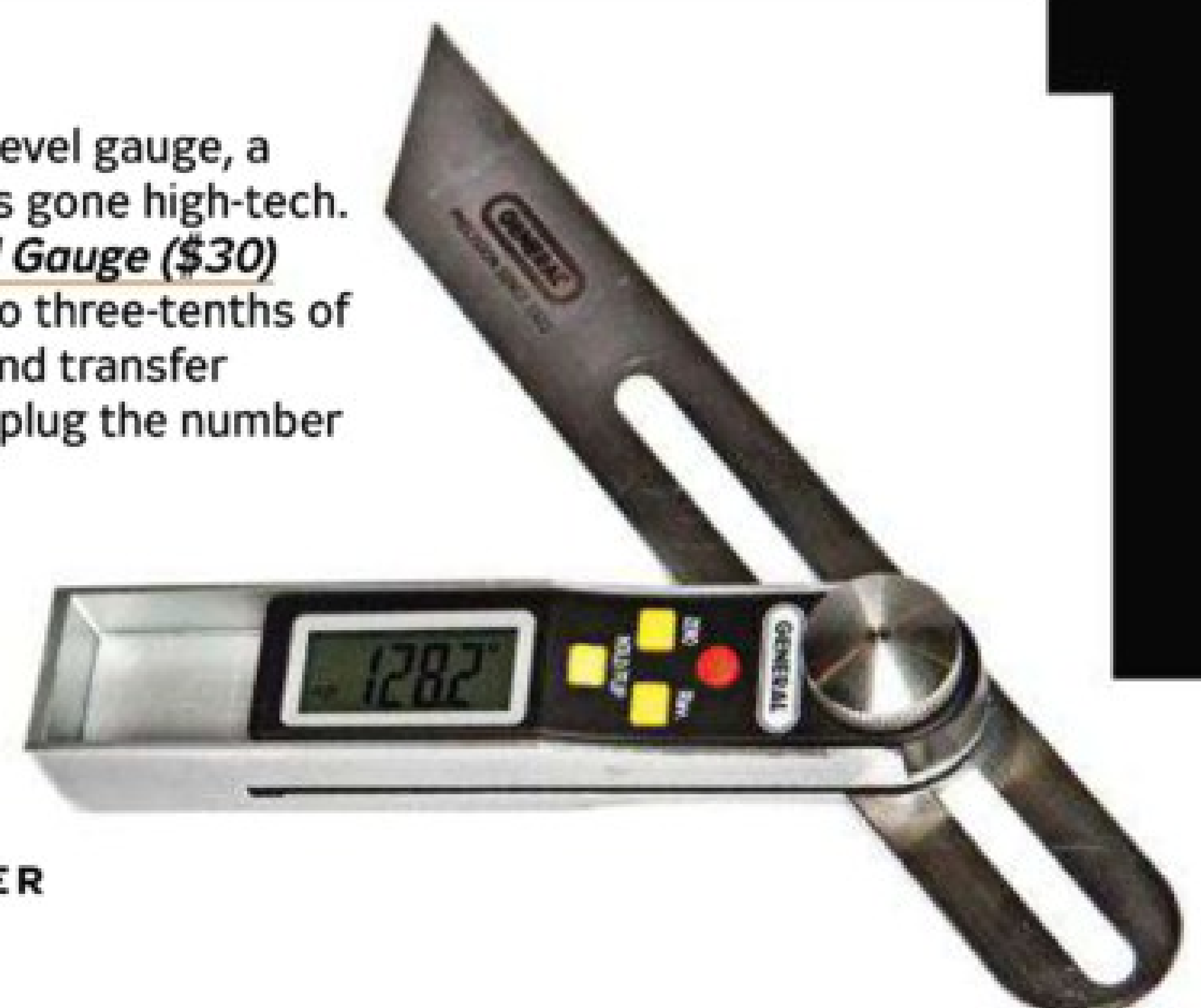


Stud Saddles

↓ Plywood sags if it's stretched across two sawbucks, but the steel brackets of *Rockler's Sawhorse Supports* (\$13) span a 2 x 4 across the gap. The extra lumber supports a sturdy work platform safe to use for power tools, paint or lunch.

↑ The *Solo 814 ES Cut-Off Saw* (\$1100) invites hot-knife-through-butter comparisons whether it's slicing stone, concrete or—in the hands of Chris Grundy, above, host of the DIY Network's *Cool Tools*—a 2-inch steel angle iron. The easy-to-use tool blends its own two-stroke engine fuel. Gas and oil go into separate tanks, and timed injections mix the ingredients within the engine's single cylinder. Thanks to an electronic, automatic choke, Grundy fired up the Solo with just two pulls. Getting him to stop was tougher. Cut after cut, he said, "Yeah, baby! That's what I'm talkin' about!"

Digital Bevel → The sliding T-bevel gauge, a tool almost as old as the hammer, has gone high-tech. *General Tools' Digital Sliding T-Bevel Gauge* (\$30) displays and stores angles accurate to three-tenths of a degree from 0 through 360. Copy and transfer angles in the traditional way—or just plug the number straight into a miter saw.



PHOTOGRAPHS BY JACOB KEPLER



Super Square

↑ The Swanson Speed Square has been a go-to tool since its invention in 1925. It's a rugged circular-saw guide and a compact rafter square, to name just two of its many uses. With two new hinges, the Speed Square becomes the **Swanson Speed Bevel (\$9)**. It folds out into a sliding T-bevel to transfer and mark angles. It forms a guide to mark long parallel lines or drywall cuts. And it still helps lay out complex rafter cuts when not guiding saws through a square crosscut. Who says you can't improve on perfection?

Port-a-Pump

↓ It weighs just 3.6 pounds, but Rule Industries' **AquaCharge (\$90)** is no pipsqueak pump. Able to operate partially or fully submerged, it can move 200 gallons of salt water or fresh water on a nickel-metal-hydride battery charge. Use it to bail canoes, empty wet-dry vacs or sop up a soggy basement.



Saw to Go → An ergonomic wonder, the **Bosch 10-inch Worksite Table Saw (\$399)** packs a rip fence, a miter gauge, a blade guard and a 15-amp motor into a 52-pound package well-balanced enough to be carried with one hand. Fold it and go. Unfold it and get to work.



Rockwell's engineers kept a careful eye on the details when designing the **VersaCut (\$130)**, a 4-pound powerhouse that cuts plywood, composites, lumber, light-gauge sheet metal and ceramic tile. The secret is a 4-amp motor paired up with blades for specific materials and cuts. Use the carbide-tip 24-tooth blade for fast and rough wood cutting. To cut metal, install a 44-tooth blade made of tough high-speed steel. For tile, turn to the saw's abrasive diamond blade. About the only thing the saw doesn't cut is features: It comes with the three blades, a dust-extraction port and an edge guide.





Behold, the Commode

When asked to name the Chevy of the toilet world, salesman David Braunig at Houston's Stanco Plumbing Specialties offers the same answer that many contractors across the country do: the American Standard Cadet 3. Stanco sells about 60 of them a month, and plumbers—from New Jersey's Russo Bros. & Co. to Cincinnati's Dick Scott Plumbing—install about one a week. "People hear 'American Standard,' they think quality," Scott says. He's worked his trade for 45 years, but the Cadet has been around for 66: Its debut listing in a 1945 catalog touted a "Syphon Action Reverse Trap Bowl" that dispatched 10 gallons per flush (GPF). The newest model, which costs about 200 bucks, entered the 2011 Kitchen & Bath Industry Show with its consumption cut to 1.28 GPF, the industry's low-flow benchmark. Congrats, Cadet. Keep on chugging. — HARRY SAWYERS

Dream Thrones

Three new luxury flushers are making a splash. But with their swanky features, investment-level price tags and sophisticated technology, the fixtures seem to defy their prosaic purpose. Are these fancy cans too good to actually use?



Kohler Numi
(\$6390)

With an iPod dock, audio speakers, a bidet, foot heaters, a remote-controlled flush and sensors that lift the seat when confronted by a man, the dual-flush Numi does it all. What the handle-free electric john doesn't do, if the power goes out and the backup battery dies, is flush.



Duravit SensoWash
(\$2255)

Designer Philippe Starck lends a slick minimal style to a toilet distinguished by a heated seat, an LED night light, a washing wand with three profiles and another remote control. The remote is an odd idea—how far from the action could you be?



Toto Maris Suite
(\$800)

Luxury in the Maris Suite is more about engineering than mere extravagance. Installers customize the seat height. Water swirls in a recessed concave channel rather than drizzling down a rim. An elongated, skirted bowl cleans easily, and the curved tank just looks inviting.

TOILET TRAINING

The standard toilet-testing load—known as a unit—is a condom full of 50 grams of miso paste. Engineers flush six units to simulate a typical man's demands. At trade show demos, folks toss in 10 units at a time. The ½-kilo test proves the loo can handle even the toughest encounters.



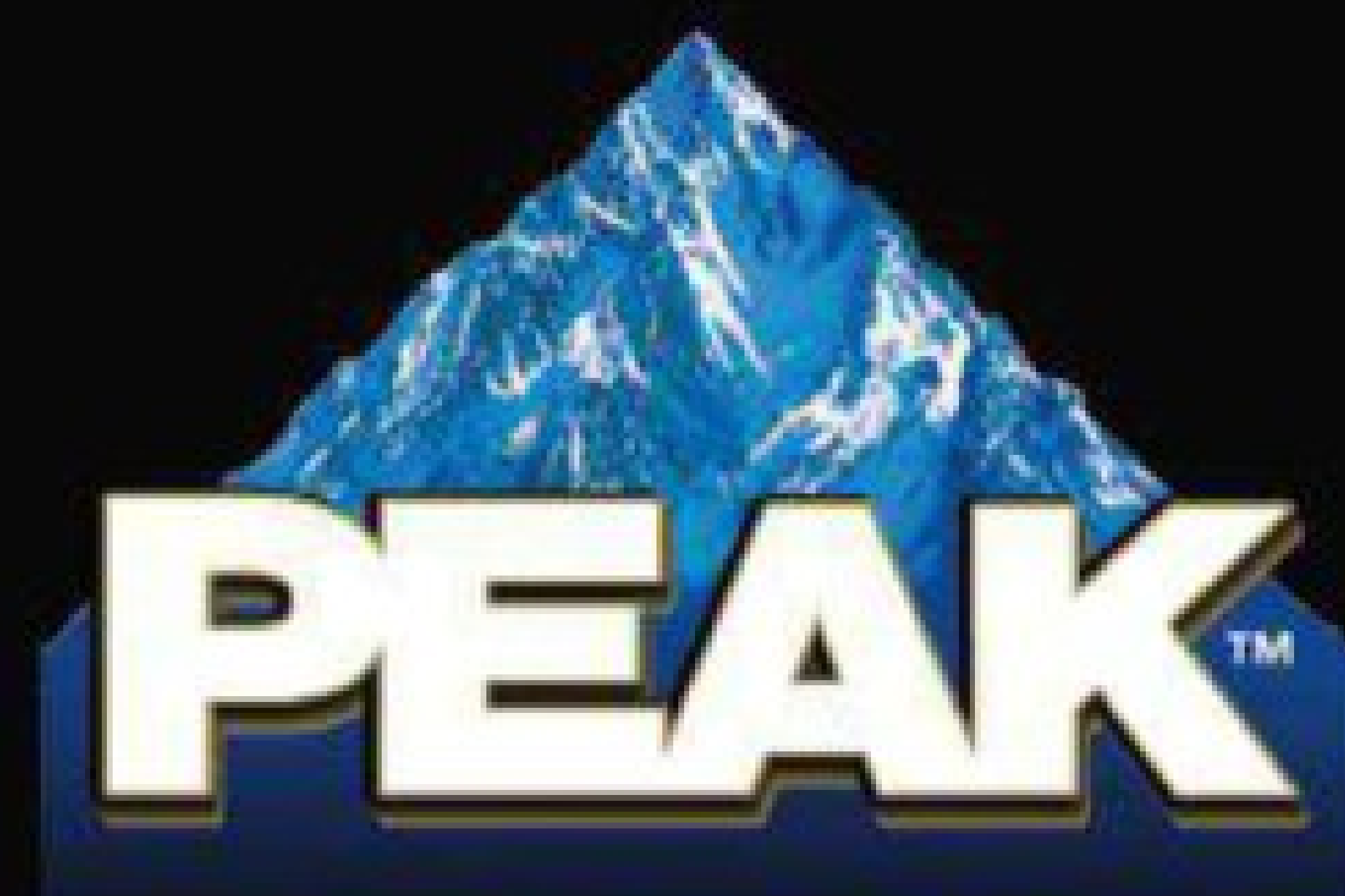
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Tablet Showdown

After a year and a half, the iPad suddenly has challengers. We examined six tablets, four operating systems and three screen sizes to see how the slates stack up.



1 Apple iPad 2
(\$499–\$829)

DIMENSIONS

9.5 X 7.3 X 0.34 INCHES

WEIGHT

1.3 POUNDS

SCREEN

9.7 INCHES; 1024 X 768

OPERATING SYSTEM

APPLE IOS 4.4

**PERFORMANCE
(CHIP; STORAGE)**

1 GHZ DUAL-CORE APPLE A5;
16–64 GB

CONNECTIVITY

WI-FI, 3G, HDMI ADAPTER
SOLD SEPARATELY

HARDWARE

This second-gen tablet feels comfy and solid, though still a bit heavy for something so thin.

SOFTWARE

Easiest to use and navigate, but has no home-screen widgets for weather or email. Apple's App Store crushes all other options.

ENTERTAINMENT

The 4:3 aspect makes the iPad 2 great for reading books and magazines, but widescreen movies get cramped.

WHO IT'S FOR

Anyone who doesn't hold a grudge against Apple.



2 Motorola Xoom
(\$599–\$799)

9.8 X 6.6 X 0.52 INCHES

1.60 POUNDS

10.1 INCHES; 1280 X 800

GOOGLE ANDROID 3.1

1 GHZ DUAL-CORE NVIDIA
TEGRA 2; 32 GB

WI-FI, 3G AND 4G, HDMI,
MICRO USB, MICRO SD

The Xoom feels cheap and plasticky but has a killer screen with sharp contrast.

Updated from 3.0 to 3.1, Android on the Xoom is a work in progress. But with Flash support and a fast-growing app market, the OS is promising.

16:10 is great for video, but Android Market rentals are the only easy way to get movies onto the device.

People willing to take a gamble on the future of Android.



3 Acer Iconia Tab A500
(\$450)

10.2 X 6.97 X 0.52 INCHES

1.69 POUNDS

10.1 INCHES; 1280 X 800

GOOGLE ANDROID 3.0

1 GHZ DUAL-CORE NVIDIA
TEGRA 2; 16 GB

WI-FI, MICRO AND FULL-SIZE
USB, HDMI, MICRO SD

A thick but solid machine for the price. Screen is a bit milky compared to the competition's.

Still on Android 3.0, our Iconia lacked 3.1's multitasking and Flash support. No Microsoft Exchange email limits the Iconia's corporate appeal.

Hard to load video. Without Android 3.1's movie market, it was little more than a YouTube player. *Angry Birds* worked!

Bargain hunters who can wait for software upgrades.

It's hard to believe it now, but people predicted that no one would want tablets. Then, with the iPad, Apple created an ideal media-consumption device—and the competition emerged. Apple reformulated its phone's operating system for tablet duty, and Google (Android), Research in Motion (BlackBerry) and HP (WebOS) are doing the same. Development is so rapid that testing tablets is like shooting at moving targets—two of our models were prototypes, and three had major system upgrades during the test. Much is in flux, but one thing is for sure: No one questions the concept of tablets anymore. — **GLENN DERENE**



4 **RIM BlackBerry PlayBook** (\$499–\$699)

7.6 X 5.1 X 0.4 INCHES

0.9 POUNDS

7 INCHES; 1024 X 600

BLACKBERRY TABLET OS

1 GHZ DUAL-CORE TEXAS INSTRUMENTS; 16–64 GB

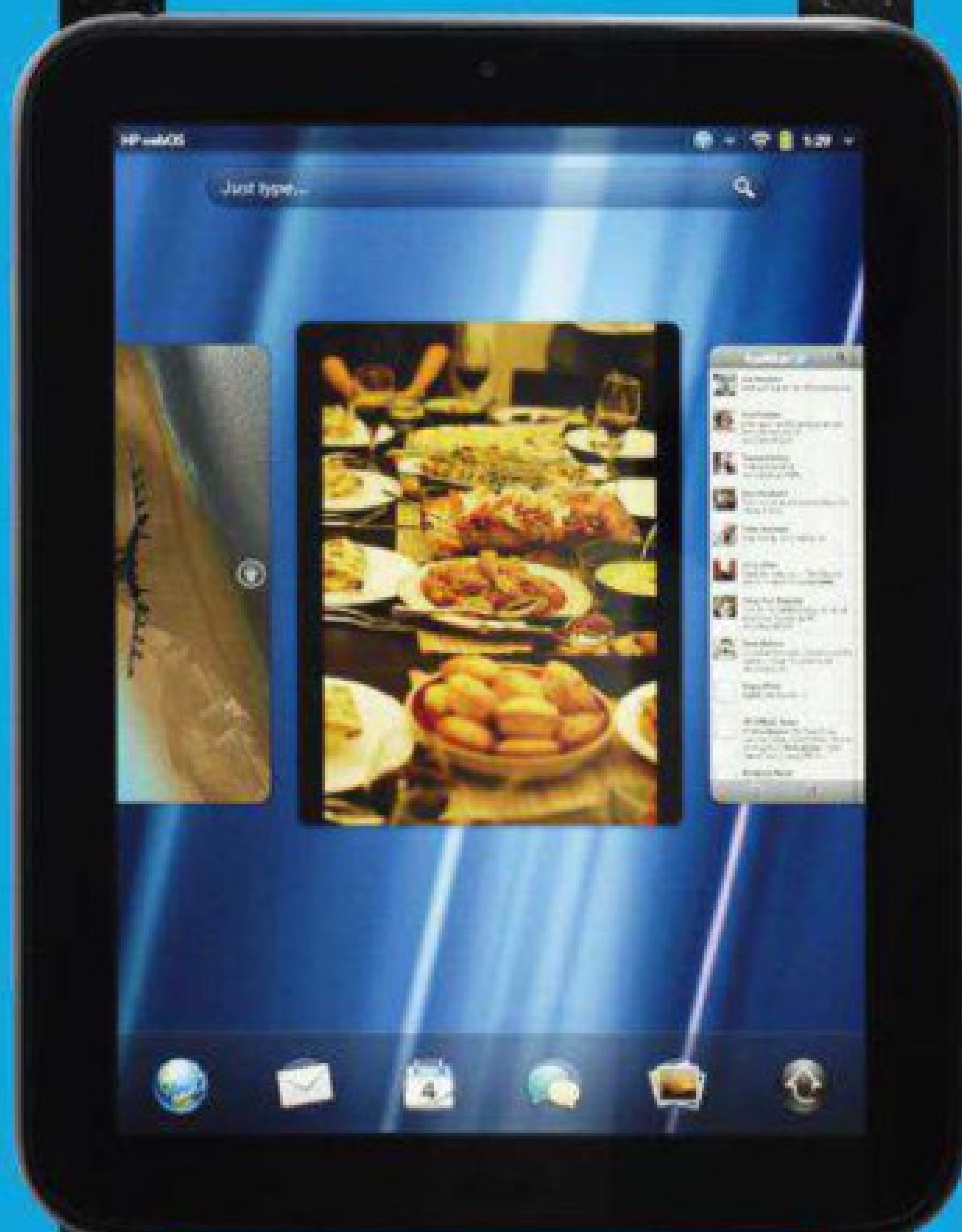
WI-FI, 3G AND 4G, MICRO USB, HDMI

This tiny tablet is well-built and comfortable to use, and had the best-looking screen in our test.

Weak apps. No email support. But the OS is a multitasking machine, with a drag-and-swipe interface that makes app management fun.

No Pandora, no *Angry Birds*, no Amazon Kindle. (RIM plans to add Android apps soon.)

Nobody, yet. A good OS doesn't make up for terrible apps.



5 **HP TouchPad** (\$500–\$600)

9.45 X 7.48 X 0.54 INCHES

1.60 POUNDS

9.7 INCHES; 1024 X 768

HP WEBOS

1.2 GHZ DUAL-CORE QUALCOMM SNAPDRAGON; 16–32 GB

WI-FI, 3G, MICRO USB, TOUCHSTONE WIRELESS

The TouchPad is almost a perfect size-and-weight replica of the iPad... the first iPad.

TouchPad's delightful OS makes Apple's iOS look boring. Its late entry into the world of tablet apps casts doubts on the TouchPad's survival.

HP supports movie downloads with its own store. Inclusion of Beats Audio should make it a standout music player.

Anyone willing to invest \$500 in an exciting, unproven format.



6 **Samsung Galaxy Tab 10.1** (\$499–\$599)

10.1 X 6.81 X 0.31 INCHES

1.24 POUNDS

10.1 INCHES; 1280 X 800

GOOGLE ANDROID 3.0

1 GHZ DUAL-CORE NVIDIA TEGRA 2; 16–32 GB

WI-FI, 3G AND 4G, MICRO SD

Samsung is a featherweight, coming in a few hairs slimmer and lighter than the iPad 2.

Prototypes of the Galaxy Tab 10.1 offer an experience similar to other Android tablets. Email and calendars from Microsoft Exchange sync up—a plus.

Galaxy's 16:10 screen makes it a good movie device. Samsung should synchronize the Tab and the company's TVs.

Folks who want to break free from Apple's walled garden.



✓Yes



✓Yes



✓Yes



xNo



✓Yes



✓Yes



✓Yes



✓Yes

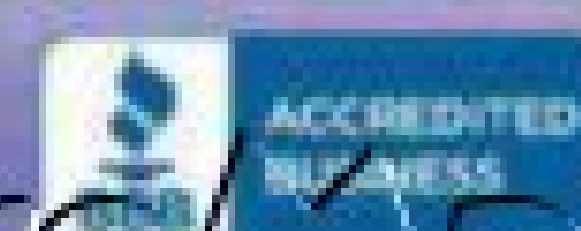


✓Yes

- ✓ Everyday Low Prices
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+ PRIUS VS CIVIC + FIAT DROPTOP

New Cars



THE ONE



2011 BMW 1M COUPE → BASE PRICE \$47,010

With the new 1M coupe, a high-performance version of its lowest-priced car, BMW is reminding us it hasn't forgotten how to build scintillating driving machines. Comparisons to the M3 are inevitable, and the 1M uses many of the same parts—the brakes, steering and rear differential among them—but it has several advantages. It's about 400 pounds lighter; the 335-hp twin-turbo six makes more torque (332 lb-ft versus 295), especially at low rpm; and the wheelbase is 4 inches shorter. Agility is the key goal here, which the 1M displayed as we zinged the car around the

tarmac of New York's Monticello Motor Club raceway. Whether we were snapping breezily through the six-speed manual that is the car's only transmission, rotating the blunted tail easily with the throttle or directing the nose with the perfectly weighted steering, the 1M proved a dynamic delight and made us feel like a pro driver. Options are especially slim on this car—the only choices are color (there are three) and whether to get electric seats and a navigation system. But who's counting? We'll take another lap. Only 1000 1Ms will be offered this year, but please, BMW, make more cars just like it. — *MICHAEL FRANK*

2011 Jeep Compass

CVT with
8.14:1
final drive
transmissionSkidplates
protect the belly

Trail-Rated

Is a Jeep really a Jeep if it can't go off-road? That was the problem with the old Compass—it was the only vehicle in the line that wasn't "Trail Rated." For 2011, Jeep has fixed the problem by offering the \$1600 Freedom Drive II Off-Road Package on almost every model, even the low-priced \$20,995 Sport 4WD. It includes raised ride height, skidplates, a special CVT with a short final drive to achieve 19:1 overall gearing, better tires and more. For the most part, the new hardware does the job. On the famous Fins and Things Trail in Moab, Utah, we drove the Compass over terrain we'd never attempt in other compact SUVs, although some of the steeper rock pitches required a running start and steering corrections to ascend. At least descending was effortless, thanks to the Hill Descent Control, which automatically worked the brakes to stay at crawl speed. Just don't expect to follow a Wrangler on the hardcore Rubicon Trail. Then again, a Wrangler doesn't handle like a car or return well north of 20 mpg.

— BEN STEWART

2012 Toyota Prius V



HYBRID OFFSPRING Toyota is making the Prius hybrid its own brand, like Lexus, and has unveiled the first variant, the Prius V. The V stands for versatility, and for this firstborn, Toyota has enlarged the standard hatchback. It's taller and wider, with a wagon-like back. There's 50 percent more rear cargo room, and spacious rear seats that adjust fore and aft and recline. The V retains the Prius gas-electric powertrain and nickel-metal-hydride battery pack, but thanks to greater aero drag (the coefficient of drag increases to 0.29 from 0.26) and roughly 200 more pounds, the V doesn't match the regular car's 50 EPA combined-mpg figure. Still, it returns a stellar 42. More space doesn't alter the driving experience, which remains Prius-esque—quiet and refined, but not especially engaging. The V will start at roughly 25 grand and will debut Toyota's cloud-based suite of in-car entertainment apps, Entune. — ERIC TEGLER

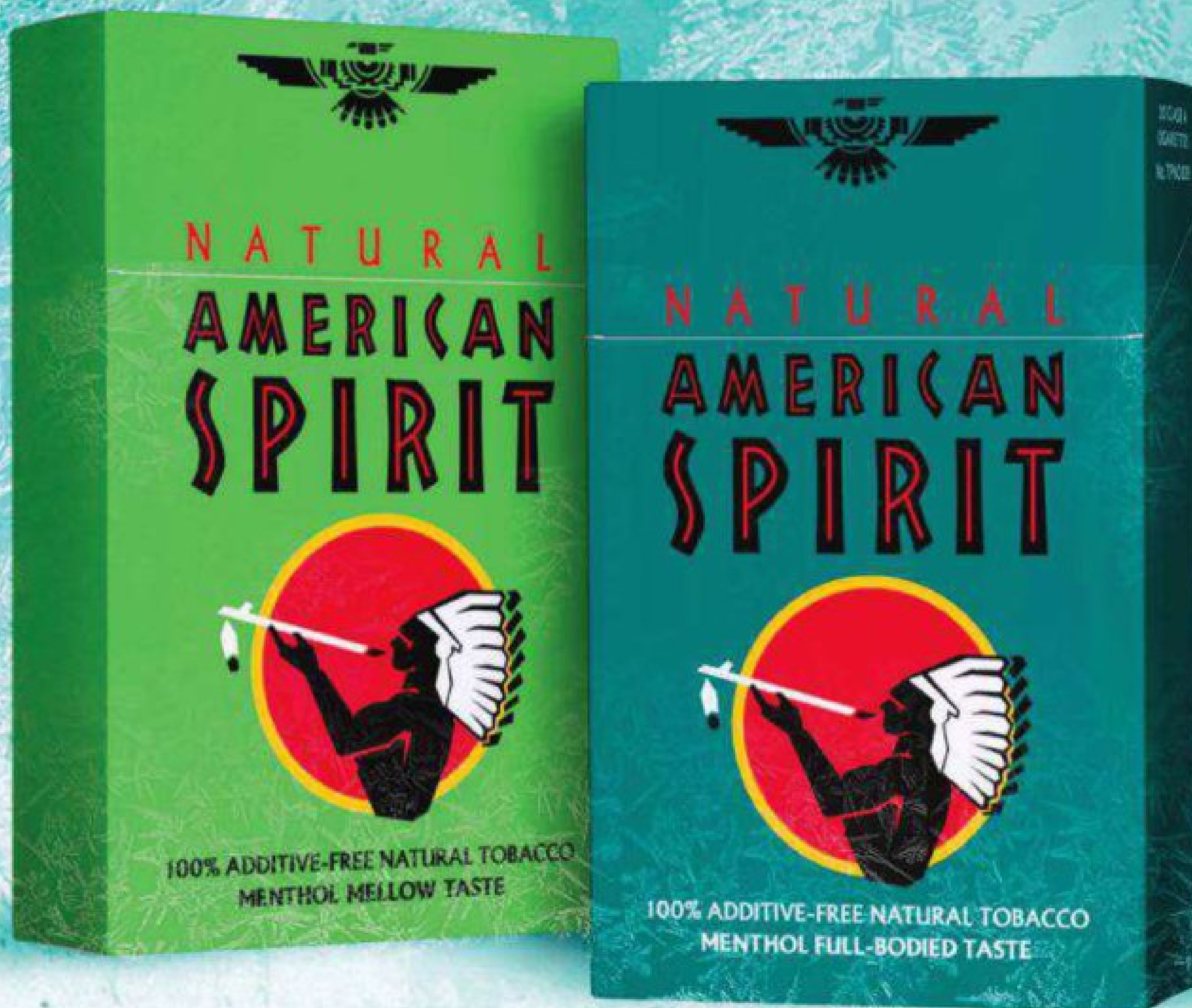
2012 Porsche Panamera S Hybrid



ELECTRIC GT The Porsche Panamera S Hybrid is not just a hybrid making a total of 380 hp and 428 lb-ft of torque from a 333-hp, supercharged 3.0-liter V6 and a 47-hp electric motor—it's now the definitive luxury hybrid. And that's in spite of its odd proportions. The car easily wins favor by way of its stunning interior, impeccable road manners and silky smooth power. Blasting around the finely paved mountain roads outside Salzburg, Austria, the wide Panamera made for some interesting passing moments, but it accelerated, braked and cornered like a proper GT car. That it can travel nearly 1.5 miles in all-electric mode and get up to 30 mpg is just a bonus. This is Porsche reaching into the future, where blended powertrains deliver emotional performance and rational consumption. Sadly (for us mortals, anyway), the price is equally breathtaking—it starts at \$95,975. — BEN WOJDYLA

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2012 Fiat 500c
Convertible



101 ITALIAN HORSES ▶ Fiat's first U.S. appearance in 28 years began with its retro-riffic 500, and the new 500c (\$19,500) cracks open the small-car paradigm with a power-operated soft-top that peels back in just 15 seconds. Since the top is like a giant sunroof, the car's main side structure and rigidity are preserved, yet the portal is large enough to provide that wonderful open-air experience. Plus, the lid can be operated at speeds of up to 60 mph, and there's a deflector that reduces in-cabin turbulence. Though the 101-hp engine is more suited to style-conscious drivers than speed-savvy ones, that didn't stop us from grinning all the way from Manhattan's urban jungle to the rambling country roads of Dutchess County, 75 miles north. — *BASEM WASEF*

2012 Mercedes-Benz
C-Class



CLASSY COUPE ▶ The Mercedes-Benz C-Class is now fit to go 10 rounds with the BMW 3 Series, thanks to the introduction of the C-Class coupe. Available in three configurations, from conservative to comically powerful, the new model is a stylish supplement to the existing sedan. Engine options range from a turbocharged 201-hp 1.8-liter four-cylinder to a 302-hp 3.5-liter V6 and a 6.2-liter V8, capable of shredding tires with the help of 451 to 481 horses. All engines are coupled to a seven-speed automatic, though the brawnier V8 uses a computer-controlled clutch in place of the standard torque converter. The miserly C250 coupe is set to deliver an estimated 30 mpg on the highway, though drivers with a heavier right foot will appreciate the steroid-riddled C63 AMG coupe and its 4.4-second 0-to-60-mph time. — *JAMES TATE*

Outrageous

▶ Everything about the new Aventador screams at you, from its recession-blind price to the revved-up engine roar to the outrageous design. But it isn't all angles and engine. The Aventador is a supercar as physics experiment, with a carbon-fiber monocoque making it 150 percent stiffer than the Murciélago it replaces, an F1-style pushrod suspension system and a roboticized transmission that delivers 50-millisecond shifts. The result is a vehicle that drives much smaller than it actually is and barely tilts off axis, even during the hardest cornering. And let's not forget that 691-hp V12 engine and AWD system that help it hit 62 mph in a scant 2.9 seconds. — *GLENN DERENE*





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Hybrid Mileage Test

With a more capable hybrid system, can Honda's new Civic out-economize a Toyota Prius?

BY BEN STEWART



++

2012 Honda Civic Hybrid

\$24,800
\$27,500
44/44 mpg
43.7/47.1 mpg

BASE PRICE
AS TESTED
EPA CITY/HWY
PM CITY/HWY

2011 Toyota Prius

\$22,880
\$24,369
51/48 mpg
50.2/51.4 mpg

BOTTOM LINE

In our test, both hybrids exceeded their EPA ratings on the highway: The Prius returned 51.4 mpg compared with the Civic's 47.1. The numbers changed in the city loop, but not the trend: Prius, 50.2; Civic, 43.7. Clearly, the Prius is still the fuel-economy king, but there is no loser here. For less than 30 grand, both of these cars offer technology that returns incredibly high fuel economy.

the SPECS

Like the rest of the Civic lineup, the Civic Hybrid has been re-engineered for 2012. The Honda's basic architecture remains (the electric motor is sandwiched between the gas engine and CVT transmission), but there are several key changes: Engine displacement has been increased to 1.5 liters, the electric motor produces more peak power (23 hp versus 15 hp), and the battery pack now uses lithium-ion chemistry with higher energy storage (0.65 kilowatt-hours). Those changes and tweaks to the aerodynamics and rolling resistance have increased the EPA fuel economy ratings to 44 mpg in both the city and highway categories.

On paper, these figures do not overtake those of Toyota's Prius, which earns 51/48 EPA city/highway numbers. But we've seen before that those EPA figures don't often match what we record in real-world driving conditions. So we obtained both cars and hit the highways and city streets of Southern California to see if Honda's latest hybrid could unseat the champ.



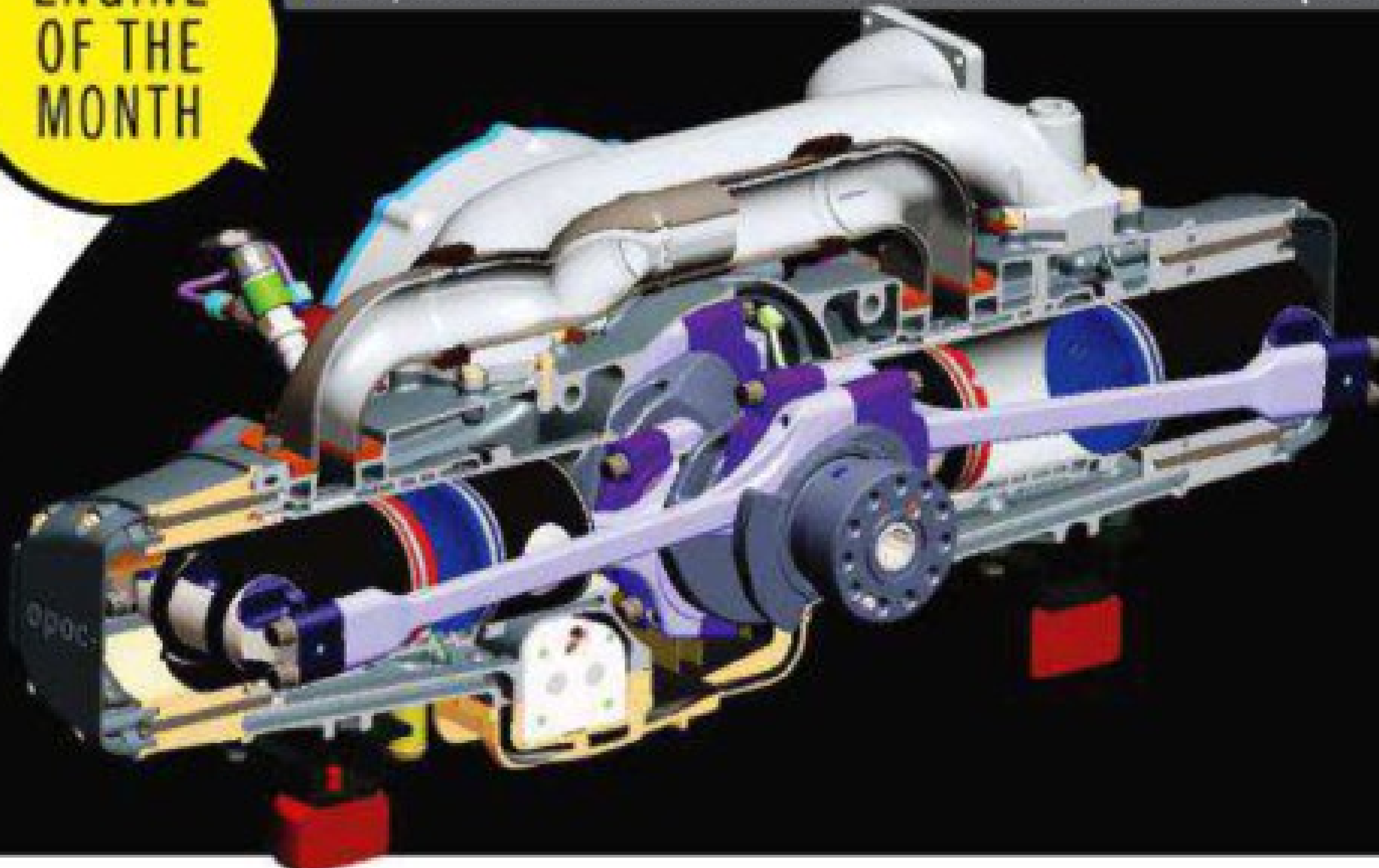
the DRIVE

We split the drive into two parts, city and highway, covering about 650 miles over two days. To cancel the effects that different driving habits can have on economy, we switched cars often.

While we noticed that both cars feel similar (they ride on the same-brand and same-size tires), the Honda is just a tick more polished—there's less freeway hum inside, and it's not as susceptible to crosswinds. The Prius, however, offers more rear legroom and about double the cargo space compared with the Civic's. But, really, we're splitting hairs—both of these cars are supremely comfortable cruisers.

ENGINE OF THE MONTH

NEW, EXPERIMENTAL AND OFFBEAT MOTORS THAT MAY (OR MAY NOT) ONE DAY POWER A CAR



EcoMotors Opposed-Piston Engine

HOW IT WORKS // Two pistons share a cylinder, and they're attached to the crankshaft 180 degrees apart. The combustion chamber is actually between the two pistons. The gases enter and exit the cylinder via ports in the cylinder walls. There's also a turbocharger that's kept spinning by an electric motor to reduce lag. The advantages of this design are many: There's no cylinder head or valves, and its power density is high. With funding from Bill Gates and others, EcoMotors International is developing the engine for commercial use (it was originally intended for the military). If the engine hits the road, it will most likely appear first in semi trucks because it's modular—pairs of cylinders can be added with the cranks joined by a clutch—so unneeded cylinder pairs can be efficiently idled. — BEN WOJDYLA



LEXUS LF-GH CONCEPT

+ One role of concept cars is to introduce a brand's upcoming styling direction. This concept previews design cues that Lexus hopes will enliven its conservative lineup.

[2011] New York International Auto Show

Once the ideal venue to showcase the latest luxury rides, this year's New York auto show reflected the industry's focus on fuel economy and debuted more gas sippers than fat cats. *BY MICHAEL FRANK*

1. 2012 VW BEETLE

VW's New Beetle is lower and wider, and Volkswagen promises better fuel economy and improved handling. A feature that sounds a lot like Ford's Curve Control (the computer brakes the inside front wheel to tighten the car's arc during turning) will be optional.

2. MERCEDES A-CLASS CONCEPT

Mercedes will take another swing at the compact-car segment with a version of this very handsome concept. When the production A-Class debuts within two years, expect front-wheel drive, a four-cylinder engine and maybe a hybrid.

3. 2013 CHEVROLET MALIBU

This once domestically skewed sedan was shown in China a day before its U.S. unveiling. The new version is slightly wider,

with a larger trunk. An Eco model will feature the eAssist system, boosting fuel economy to a very respectable 38 mpg.

4. 2012 NISSAN VERSA

We are sure the new Versa is quieter and more pleasing to drive than the outgoing car. And it offers good fuel economy (30/37) at a very low price (around \$11,000). But with its dowdy exterior and dinky 15-inch wheels, this could be the most forgettable car we've seen in years.

5. SCION FR-S CONCEPT

Scion's FR-S Concept is Toyota's version of the coupe that's being jointly developed with Subaru. Under the hood is a Subie 2.0-liter flat-four engine that drives the rear wheels. We can only hope it delivers the driving dynamics that the swoopy shape suggests.



1



2



3



4



5

DIY Auto Infotainment System

New-car infotainment systems, like Ford's Sync, offer a terrific suite of features that include hands-free calling, voice commands, music-player integration and navigation. But what if you have an older car or a new one with just a radio? Here are three ways to make your car stereo smarter. *BY LARRY WEBSTER*

METHOD

CHEAPSKATE



A smartphone and a stereo with an auxiliary jack

SENSIBLE



Parrot MKi9100 controller

GOLD-PLATED



A new head unit

REQUIRED
HARDWARE

COST

About \$35, not including the smartphone

\$229

About \$750 and up

SETUP

SMARTPHONES, SUCH AS THE iPhone or those running the Google Android OS, are like handheld infotainment systems: They play music, have built-in GPS nav systems and even understand voice commands. The trick is making them convenient to use in the car. For our iPhone, we used three parts: a \$10 mount, a \$20 remote mic/Home button and a \$5 auxiliary cable to connect the phone to the car stereo. **When prompted first with the Home button, the iPhone responds to voice commands to find music ("play Ted Nugent") or retrieve numbers from your contact list ("call Ted Nugent").** Most Android devices have similar functionality. Don't know your phone's voice commands? There are smartphone apps that catalog the standard ones, and programs that let you customize (although you'll have to jailbreak the iPhone). Smartphones can also stream online radio, such as Pandora—naturally, they mute music to allow for incoming calls.

PARROT'S SYSTEM ALLOWS ANY car stereo to work with Bluetooth phones and music players. The radio has to be removed so the Parrot wiring can be married to the car's radio harness. There's a 4-inch screen and a microphone that also require mounting. The process takes only a couple of hours and can be done by a novice. In addition, there's a small thumbwheel that attaches to the steering wheel and controls most of the functions. **Once installed, the Parrot system works just like a new-car infotainment system, hooking up to any Bluetooth phone and downloading the contact list for retrieval via voice commands.** An included USB cable enables the use of almost any audio device. The Parrot system automatically mutes the audio when a call comes in and can even read and send text messages, but that feature requires using a third-party service and setting up new contacts.

SEVERAL COMPANIES, INCLUDING Pioneer, Alpine, Kenwood and Parrot, offer aftermarket infotainment systems housed in car stereos. In this arena, there are countless options that vary in price. For example, Pioneer's AVH-P6300BT (\$839) can control an iPod, stream Pandora through a smartphone and connect to a phone via Bluetooth. But while it does display contacts on the 7-inch retractable touchscreen, it doesn't respond to voice commands or have GPS navigation. For those additional features, you'll have to upgrade to a unit like the Kenwood DNX9980HD (\$1500). The Kenwood also plays videos and can be equipped with a rearview camera. **Be sure the unit fits your car—duh—and check out Crutchfield for DIY install kits.** Since we've found that the functionality can vary—the navigation screens tend toward the primitive, for example—shop at a retailer where you can try before you buy.

BOTTOM
LINE

Not the tidiest method, but capitalizes on the extremely powerful smartphone.

The most elegant and cost-effective way to mimic a new-car infotainment system.

Only worth considering if you are bent on replacing an existing stereo.

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Engine Guarantee registration required by 125,000 miles. See Valvoline.com for detailed benefits and limitations. Valvoline has already pledged \$100,000 to Keep America Beautiful, up to a maximum of \$250,000. © 2011, Ashtand Inc.

www.KeepAmericaBeautiful.com



Go to cymbalta.com for a free 30-capsule trial offer.

Cymbalta can help.

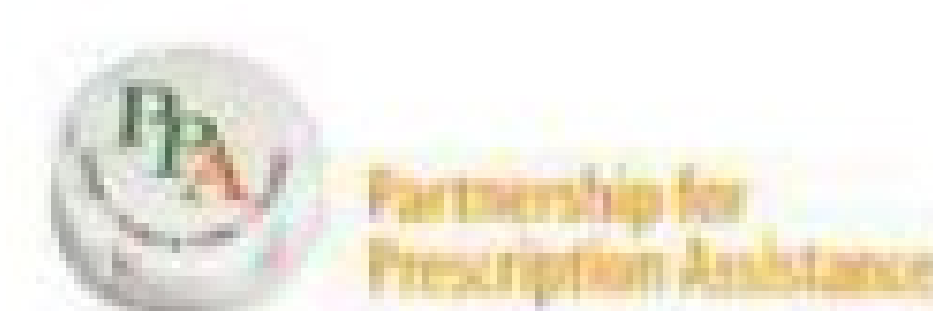
Cymbalta is a once-daily, non-narcotic pain reliever. And it's not addictive.

When taken once a day, every day, Cymbalta is proven to significantly reduce chronic low back pain.

You may have to rethink the way you treat your pain. You might be used to taking pain medications only after you feel your chronic low back pain getting worse. Managing this pain with Cymbalta is a little different. It's important to take Cymbalta every day, as prescribed by your doctor, to manage your pain over time.

Visit cymbalta.com or call 1-877-CYMBALTA (1-877-296-2258) to learn more. Ask your doctor about Cymbalta.

Cymbalta is a prescription medication approved for the management of chronic musculoskeletal pain in people with chronic low back pain.



If you need assistance with prescription costs, help may be available. Visit www.pparx.org or call 1-888-4PPA-NOW.

Important Safety Information About Cymbalta

The most important information you should know about Cymbalta:

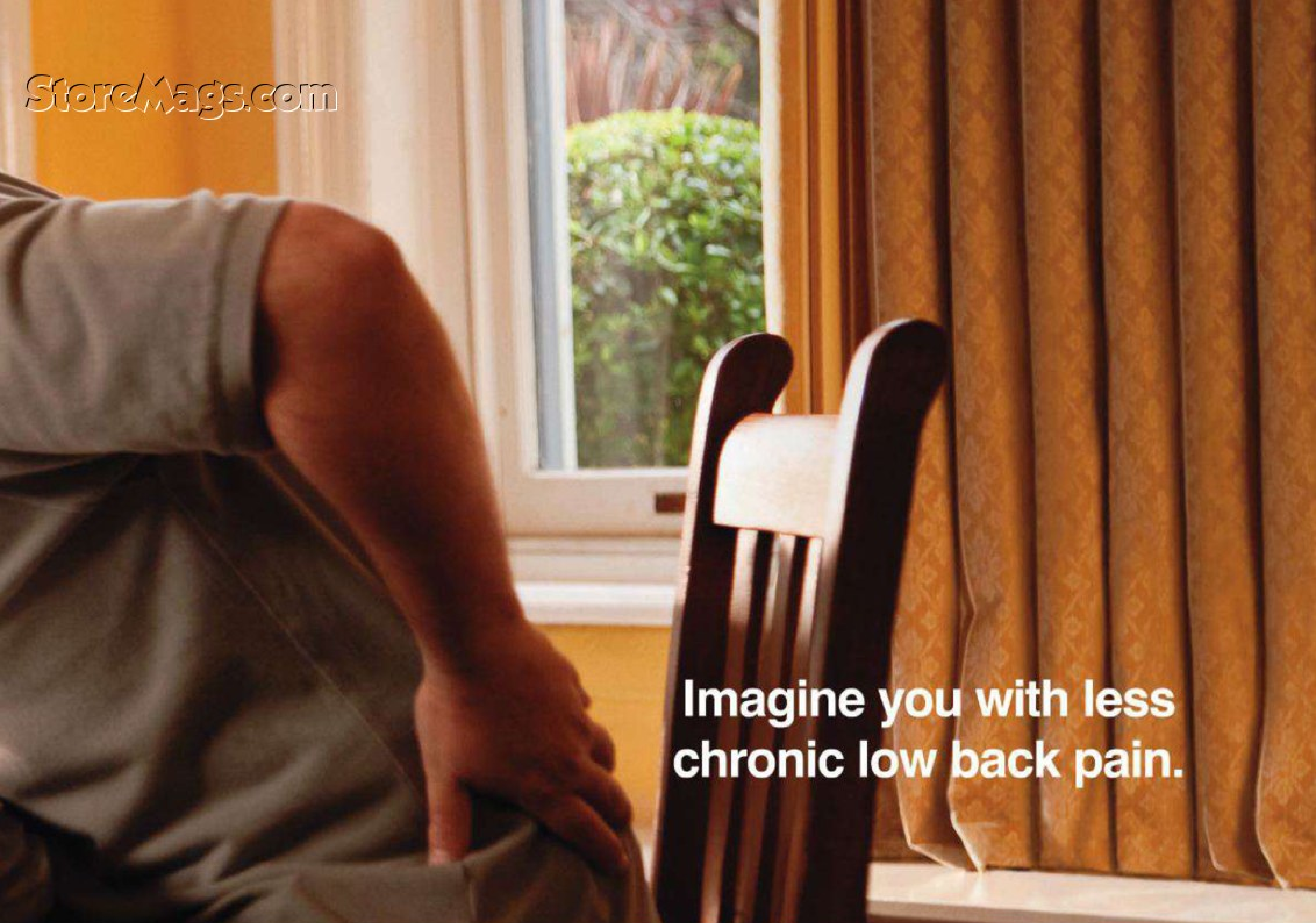
Antidepressants can increase suicidal thoughts and behaviors in children, teens, and young adults. Suicide is a known risk of depression and some other psychiatric disorders. Call your doctor right away if you have new or worsening depression symptoms, unusual changes in behavior, or thoughts of suicide. Be especially observant within the first few months of treatment or after a change in dose. Approved only for adults 18 and over.

Cymbalta® (duloxetine HCl) is not for everyone. Do not take Cymbalta if you:

- have recently taken a type of antidepressant called a monoamine oxidase inhibitor (MAOI) or Mellaril® (thioridazine)
- have uncontrolled narrow-angle glaucoma (increased eye pressure)

Talk with your healthcare provider:

- about all your medical conditions, including kidney or liver problems, glaucoma, diabetes, seizures, or if you have bipolar disorder. Cymbalta may worsen a type of glaucoma or diabetes
- if you have itching, right upper belly pain, dark urine, yellow skin/eyes, or unexplained flu-like symptoms while taking Cymbalta, which may be signs of liver problems. Severe liver problems, sometimes fatal, have been reported



**Imagine you with less
chronic low back pain.**

Important Safety Information (continued)

- about your alcohol use
- about all your medicines, including those for migraine, to address a potentially life-threatening condition. Symptoms may include high fever, confusion, and stiff muscles
- if you are taking NSAID pain relievers, aspirin, or blood thinners. Use with Cymbalta may increase bleeding risk
- before stopping Cymbalta or changing your dose
- if you experience dizziness or fainting upon standing while taking Cymbalta. This tends to occur in the first week or when increasing the dose, but may occur at any time during treatment
- about your blood pressure. Cymbalta can increase your blood pressure. Your healthcare provider should check your blood pressure prior to and while taking Cymbalta
- if you experience headache, weakness, confusion, problems concentrating, memory problems, or feel unsteady while taking Cymbalta, which may be signs of low sodium levels
- if you develop problems with urine flow while taking Cymbalta
- if you are pregnant or plan to become pregnant during therapy, or are breast-feeding

Most common side effects of Cymbalta (this is not a complete list):

- nausea, dry mouth, sleepiness, fatigue, constipation, dizziness, decreased appetite, and increased sweating

You are encouraged to report negative side effects of Prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

Other safety information about Cymbalta:

- Cymbalta may cause sleepiness and dizziness. Until you know how Cymbalta affects you, you should not drive a car or operate hazardous machinery.
- People age 65 and older who took Cymbalta reported more falls, some resulting in serious injuries.

How to take Cymbalta:

Take Cymbalta exactly as directed by your healthcare provider. Cymbalta should be taken by mouth. Do not open, break or chew capsule; it must be swallowed whole. Cymbalta can be taken with or without food.

DD CON-A ISI 21APR11

See back page for additional information about Cymbalta, including Boxed Warning about antidepressants and risk of suicide.



Cymbalta[®] DELAYED
duloxetine HCl RELEASE
20 mg, 30 mg, 60 mg CAPSULES

Lilly

Information For Patients About Cymbalta

Please read this information carefully before you, or your family member start taking Cymbalta (sim-BALL-tah), and each time your prescription is refilled, in case anything has changed or new information has become available. This information is not meant to take the place of discussions with your healthcare provider. Talk with your healthcare provider or pharmacist if there is something you do not understand or if you want to learn more about Cymbalta. Always follow your healthcare provider's instructions for taking Cymbalta.

What is the most important information I should know about Cymbalta?

Warning: In clinical studies, antidepressants increased the risk of suicidal thinking and behavior in children, adolescents, and young adults with depression and other psychiatric disorders. Anyone considering the use of Cymbalta or any other antidepressant must balance this risk with the clinical need. Short-term studies did not show an increase in the risk of suicidal thinking or behavior with antidepressants in adults older than 24; there was a reduction in risk with antidepressants in adults 65 and older. Suicide is a known risk of depression and some other psychiatric disorders. All patients starting antidepressant therapy should be monitored appropriately and observed closely. Families and caregivers should discuss with the healthcare provider right away any observations of worsening depression symptoms, suicidal thinking and behavior, or unusual changes in behavior. Cymbalta is not approved for use in patients under age 18.

Patients on antidepressants and their families or caregivers should watch for new or worsening depression symptoms, unusual changes in behavior, and thoughts of suicide, as well as for anxiety, agitation, panic attacks, difficulty sleeping, irritability, hostility, aggressiveness, impulsivity, restlessness, or extreme hyperactivity. Call your healthcare provider right away if you have thoughts of suicide or if any of these symptoms is severe or occurs suddenly. Be especially observant within the first few months of treatment or whenever there is a change in dose.

What is Cymbalta?

Cymbalta is a prescription medicine that is approved to treat multiple conditions. Cymbalta is approved for the treatment of major depressive disorder (MDD), also called depression; generalized anxiety disorder (GAD); the management of fibromyalgia (FM); the management of diabetic peripheral neuropathic pain, also called diabetic nerve pain (DNP); and the management of chronic musculoskeletal pain due to chronic osteoarthritis pain and chronic low back pain.

Who should NOT take Cymbalta?

You should not take Cymbalta if:

- You are taking a type of antidepressant known as a monoamine oxidase inhibitor (MAOI), such as Nardil® (phenelzine sulfate), Parnate® (tranylcypromine sulfate), or Emsam® (selegiline transdermal system). Using an MAOI with many prescription medicines, including Cymbalta, can cause serious or even life-threatening reactions. You must wait at least 14 days after you have stopped taking an MAOI before you

take Cymbalta. You need to wait at least 5 days after you stop taking Cymbalta before you take an MAOI

- You have uncontrolled narrow-angle glaucoma (increased eye pressure)
- You are taking an antipsychotic medicine known as Mellaril® (thioridazine)

What should I talk to my healthcare provider about?

Talk with your healthcare provider:

- About any medical conditions you may have, including kidney or liver problems, glaucoma, diabetes, seizures, or if you have bipolar disorder. Cymbalta may worsen a type of glaucoma or the control of blood sugar in some patients with diabetes
- If you have itching, right upper belly pain, dark urine, yellow skin/eyes, or unexplained flu-like symptoms while taking Cymbalta, which may be signs of liver problems. Severe liver problems, sometimes fatal, have been reported
- About your alcohol use
- If you are taking or plan to take any prescription or nonprescription medicines, as Cymbalta may interact with some of these products
- If you take medications known as triptans, commonly prescribed for migraines. A potentially life-threatening condition may occur when triptans are used with Cymbalta. Symptoms may include high fever, confusion, and stiff muscles
- If you take NSAID pain relievers, aspirin, or blood thinners, as these medications may increase risk of bleeding when used with Cymbalta
- Before stopping Cymbalta or changing your dose. Stopping Cymbalta may result in symptoms including dizziness, nausea, or headache (not a complete list). Your healthcare provider may wish to decrease the dose slowly
- If you are pregnant, plan to become pregnant, or are breastfeeding
- If you experience dizziness or fainting upon standing while taking Cymbalta. This tends to occur in the first week or when increasing the dose, but may occur at any time during treatment, or when used in combination with certain other drugs
- About your blood pressure. Cymbalta can increase your blood pressure. Your healthcare provider should check your blood pressure prior to and while taking Cymbalta
- If you experience headache, weakness, confusion, problems concentrating, memory problems, or feel unsteady while taking Cymbalta, which may be signs of low sodium levels
- If you develop problems with urine flow while taking Cymbalta

What should I avoid while taking Cymbalta?

- Cymbalta may cause sleepiness and dizziness. Until you know how Cymbalta affects you, you should not drive a car or operate hazardous machinery

What are the most common side effects of Cymbalta?

- In clinical studies for approved indications (depression, generalized anxiety disorder, diabetic nerve pain, fibromyalgia, and chronic musculoskeletal pain including chronic pain due to osteoarthritis and chronic low back pain), the most common

side effect was nausea

- Other common side effects included dry mouth, sleepiness, fatigue, constipation, dizziness, decreased appetite, and increased sweating

This is not a complete list of side effects. See Boxed Warning, "Who should NOT take Cymbalta?" and "What should I talk to my healthcare provider about?" See full prescribing information at www.cymbalta.com. Talk to your healthcare provider if you have questions or develop any side effects. **You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.**

What else should I know if I'm 65 or older?

- People age 65 and older who took Cymbalta reported more falls, some resulting in serious injuries

What should I do if I think I have taken an overdose of Cymbalta?

If you have taken more Cymbalta than has been prescribed for you, contact your healthcare provider, a hospital emergency department, or the nearest poison control center immediately.

How should I take Cymbalta?

- Take Cymbalta exactly as directed by your healthcare provider
- Cymbalta should be taken by mouth. Do not open, break, or chew the capsule; it must be swallowed whole
- Cymbalta can be taken with or without food
- If you miss a dose, take it as soon as you remember. However, if it is time for your next dose, skip the missed dose and take only your regularly scheduled dose. Do not take more than the daily amount of Cymbalta that has been prescribed for you
- Remember to refill your prescription before you run out of Cymbalta
- Talk with your healthcare provider before stopping Cymbalta or changing your dose

General advice about Cymbalta

- Store Cymbalta at room temperature and out of the reach of children
- Medicines are sometimes prescribed for purposes other than the ones listed. This medication has been prescribed for your particular condition. Do not use it for another condition or give this drug to anyone else
- If you have any questions or concerns, want to report any problems with the use of Cymbalta, or want more information, contact your healthcare provider or pharmacist

Additional information can be found at www.cymbalta.com.

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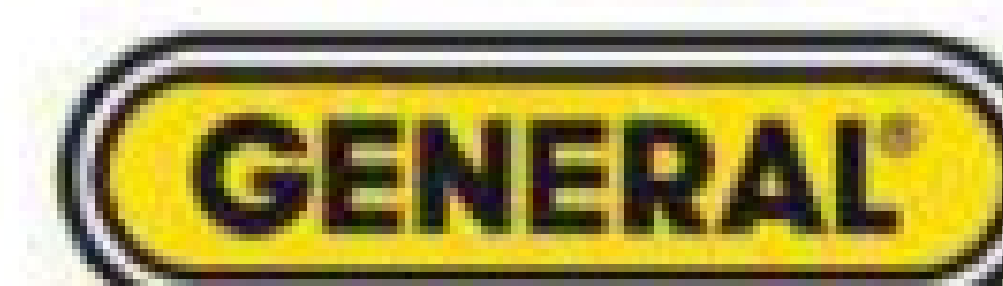
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AUTOMATED COCKPITS, NEW ENGINES, COMPOSITE PARTS: ARE MODERN PLANES OVERENGINEERED?

Wreckage from Air France Flight 447, which crashed in June 2009. The plane's black boxes were found on the seafloor two years later.

hadn't realized that bad data plagued the crew as they struggled to regain control of the aircraft. The discovery raises an important question: Are cockpits becoming so complex that pilots can no longer fly planes manually in an emergency?

Automation has helped make flying safer and easier. But some experts wonder if the rush to adopt increasingly sophisticated technology in airplanes is introducing hidden risks. Concerns extend beyond the cockpit. Environmental regulations and rising fuel costs are driving innovations in the use of lightweight composite structures—as yet untested over the life span of a commercial aircraft—and in the development of engines that run hotter and faster than ever before. According to aviation consultant and former National Transportation Safety Board (NTSB) member John Goglia, “We are pushing the technology faster than at any time in the past.”

COCKPITS: TOO SMART TO FAIL

On June 1, 2009, AF 447 was flying 35,000 feet above the Atlantic when some of its speed sensors iced over and began to malfunction. The recovered flight recorder shows that one sensor reported an immediate drop in airspeed from 275 knots to 60 knots, while other sensors reported different speeds. When a flight control computer receives conflicting data, it disengages the autopilot and the auto-thrust until the data are reconciled.

Flight Risks

> BY THE EDITORS

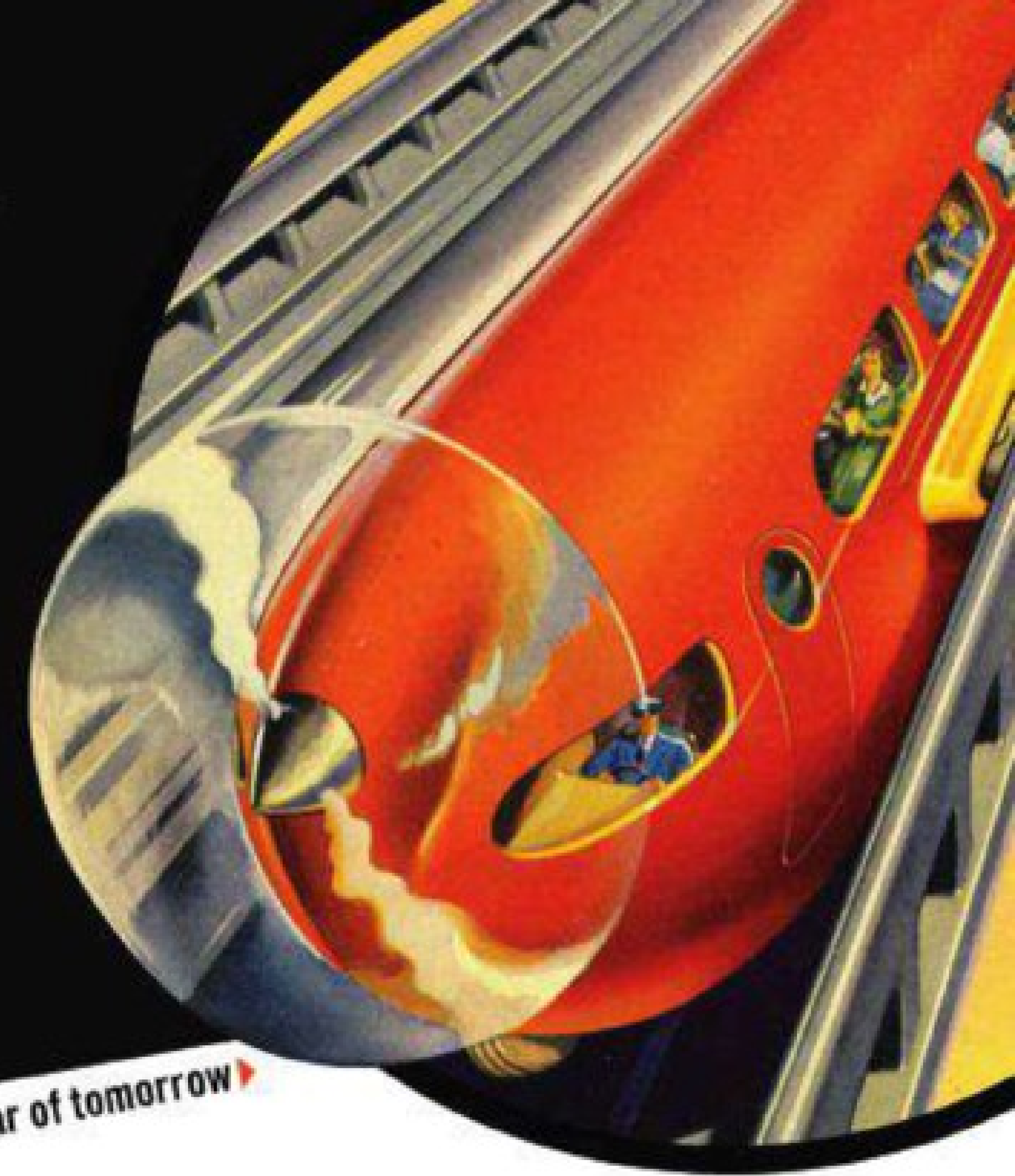
T

he eyes of the global aviation industry were focused on deep-diving robots as they swept the seafloor with side-scan sonar 2.5 miles beneath the surface of the Atlantic in early 2011. The French government, Airbus and Air France had rented the remotely operated submersibles to find the wreckage of Air France Flight 447, which had fallen out of the sky in 2009. Officials were still looking for answers to explain why an Airbus A330, one of the world's most sophisticated planes, had plunged into the ocean, killing all 228 passengers and crew.

On May 2, the robotic arm of a submersible scooped up an orange cylinder that investigators had sought for nearly two years—AF 447's cockpit voice recorder. French aviation authorities believed that a mechanical malfunction had caused sensors to feed conflicting information to the plane's flight computer, which then disengaged the autopilot. Until investigators heard the recordings, they

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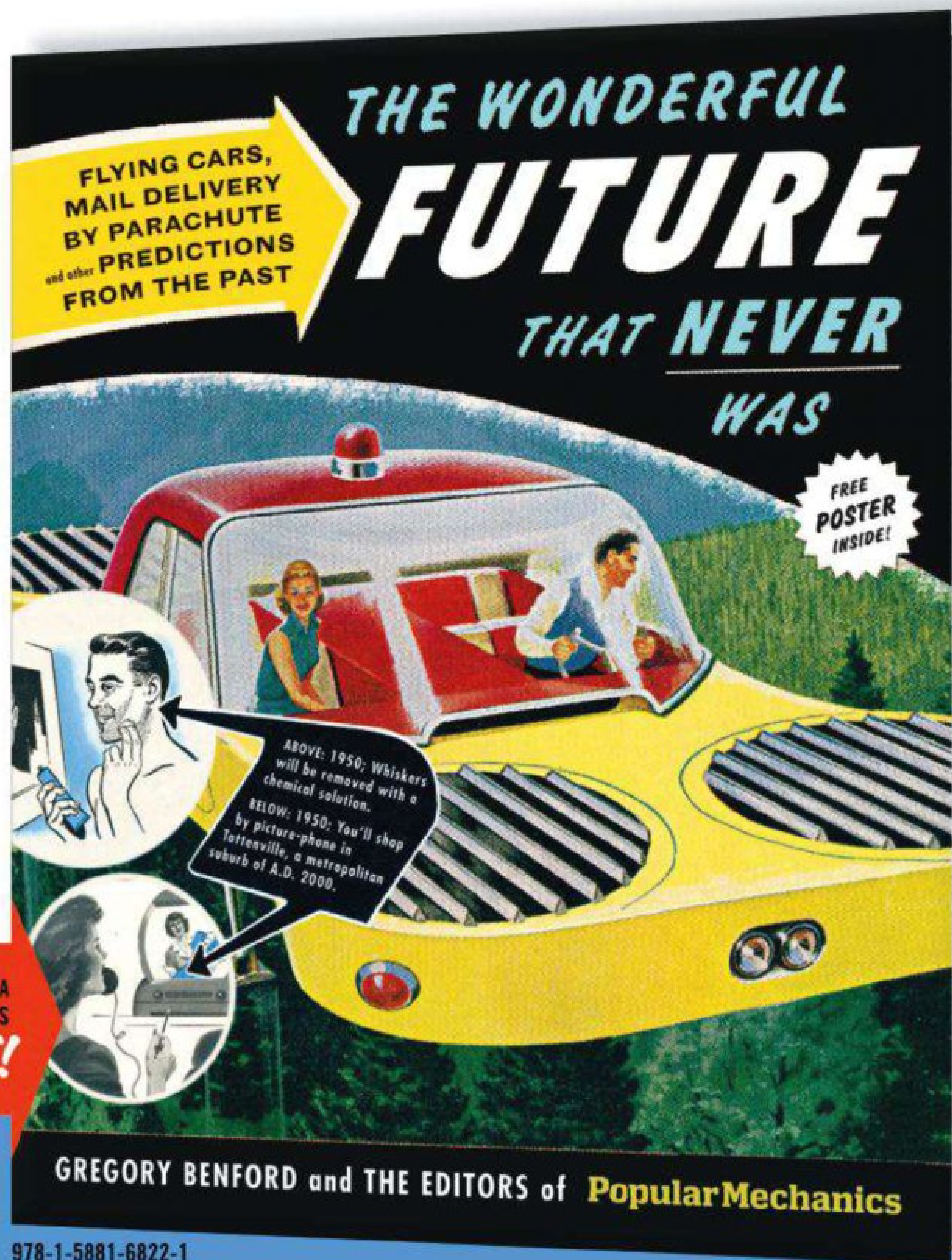
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AVIATION SAFETY /// FLIGHT RISKS

With the pilot on a rest break, the co-pilots took over manual control of the aircraft and climbed to 38,000 feet, possibly to escape turbulence. Moments later, the airplane stalled and began to fall. Instead of countering the aerodynamic stall by pointing the plane's nose down, the co-pilots kept the nose up. "It still makes no sense," says John Cox, an aviation safety consultant with 40 years of experience as a commercial airline pilot.

Meanwhile, the sensors continued to deliver inaccurate information, showing airspeeds so low that the flight control systems rejected the data. (On the recording, the co-pilots say they have "no valid indications.") As the co-pilots fought to control the plane, it began to plummet nearly 11,000 feet per minute. Four and a half minutes after the autopilot disconnected, the jet struck the water.

Airbus has declined to comment on these latest revelations. In May, the manufacturer told its customers that the recorder data did not reveal any urgent safety problems. Since 2007, however, European regulators and the Air France pilot unions had pressured airlines to upgrade the A330's airspeed sensors. Airbus responded with a replacement program, but AF 447 still had the old sensors. After the crash, regulators in Europe and the U.S. made the swap-out mandatory.

Airbus and regulators have focused on hardware, but the recovered flight control recorder has drawn attention to a more troubling aspect of the crash: the pilots' reaction to a loss of reliable data. According to William Voss, president of the Flight Safety Foundation, pilots may not be trained to transition quickly in a crisis from monitoring an automated flight to piloting a complex aircraft. "We have to get back to automation as a tool to manage the aircraft," he says. "It should be serving us, not the other way around."

In an integrated, automated airplane, one sensor breakdown can rapidly lead to others. Chesley Sullen-

berger, who landed an Airbus A320 on the Hudson River in January 2009 after bird strikes disabled both engines, told PM before the AF 447 flight recorder was recovered that failures were easier to handle in traditional cockpits with stand-alone instruments. "If they failed, [it was] recognized as a failure and easily isolated," he said. "Now, in these 'high level of integration' airplanes, there are many pieces of data that go to so many systems and so many computers. For the first time, it is possible for a single fault to have ambiguous, confusing and potentially overwhelming effects through multiple systems."

Electrical malfunctions can also disable automated cockpits. In 2008,



after an electrical glitch forced a United Airlines flight to return to Newark Liberty International Airport in New Jersey, the NTSB launched an investigation into similar incidents. The board found that since the mid-'90s, electrical malfunctions on 49 flights darkened screens, robbing pilots of essential information. If this problem occurs at a critical moment, the results could be deadly.

ENGINES: PUSHED TO THE LIMIT

Last November, 4 minutes after a Qantas A380 took off from Singapore, the pilots heard a loud bang. One of the plane's Trent 900 engines had exploded. Shrapnel punched holes in the wing, damaging spars and severing a



AF 447's flight data recorder, recovered this year and kept in seawater to prevent decay, provides new clues as to how the flight control computer failed.

main fuel line. When fuel began leaking, the automatic extinguishing system failed to activate, putting the plane in danger of catching on fire. The engine failure could have turned into a tragedy, but the pilots managed to turn the plane around and land safely. A preliminary report from the Australian Transport Safety Bureau (ATSB) traced the near-disaster to a faulty part: A stub pipe, carrying lubricating oil to a bearing, had been machined with unequal thickness, leaving it fragile. When the pipe broke,



year the Air Force finished testing a replacement composite; flight evaluation is pending.

Civilian-aircraft designers are expanding the material's applications to unprecedented levels. The Airbus A380 is 25 percent composites; half of Boeing's Dreamliner will be built of the material. Boeing estimates that the plane, with its composite construction and efficient engines, will use approximately 20 percent less fuel than current aircraft of the same size. "The composite materials on the 787 have been used, though to a significantly lesser degree, on Boeing airplanes for more than 15 years,"

leaking oil caught fire; this softened and elongated the metal of the spinning turbine blades, causing them to disintegrate and tear the engine apart. The ATSB recommended manufacturing changes; Airbus says those fixes have been made.

The faster a jet engine's turbine blades spin, the more fuel-efficient the engine becomes. In the case of a breakdown, engines are designed to eject fragments with the exhaust safely away from the fuselage and wings. But modern engines, which have parts that spin at near-supersonic speeds, risk high-energy breakdowns that can endanger the entire aircraft when a single component fails.

Such uncontained jet-engine failures are rare, which makes the incident in Singapore disturbing—and it may not be an isolated case. Rolls-Royce's T900 is similar in design to the Trent 1000, which will power Boeing's 787 Dreamliner. The T1000 delivers more than four times the power generated by the engines on a 747. Last summer, a T1000 experienced an uncontained failure on a testbed; Rolls-Royce says there is no connection between the incidents.

To cut fuel consumption, new engines are also designed to run hotter. "The fuel is being burned with the maximum control over the fuel-air mixture, at a rate to raise the internal temperature of the engine," Goglia says. "That may have played a role in

"IT IS POSSIBLE FOR A SINGLE FAULT TO HAVE POTENTIALLY OVERWHELMING EFFECTS THROUGH MULTIPLE SYSTEMS,"
CHESLEY "SULLY" SULLENBERGER SAYS.

what happened with Qantas." He and other experts say that global safety agencies need to take a closer look at the pressures the market is placing on engine-makers. "They are really being pushed to the limit," he says.

AIRFRAME: PREDICTING THE UNEXPECTED

Airline manufacturers have decades of experience with metal: They know how it behaves after cycles of pressurization and depressurization, what damages it and how to inspect it. But in another fuel-saving move, metal is being phased out in favor of carbon composites—plastic reinforced with carbon fibers—that are as strong as steel and much lighter than aluminum and titanium. But how composites will behave over the service life of a commercial aircraft is unclear.

The military has used composites for decades, and even the material in its well-maintained aircraft has failed in unexpected ways. In the late '90s, Air Force officials discovered that skin behind the engines of the B-2—an all-composite bomber put into service in 1993—was cracking. Last

spokeswoman Lori Gunter says.

Given that these materials are now used in critical structural components, Goglia and other experts contend that the existing maintenance and inspection guidelines are too vague. Current maintenance practices, which rely mainly on visual checks, may miss problems such as interior cracks that can spread unseen through composites until the part becomes unsound. To identify damage, manufacturers are developing new diagnostic tools, including ultrasonic equipment and infrared heat maps.

Historically, the aviation fatality rate has dropped sharply with each new generation of aircraft. But an unsettling fact comes with technical advances: Loss of control, which often involves human error, is now the single most common cause of air crashes worldwide. With air travel expected to grow sharply over the next few decades, the industry will need to be as aggressive about pilot training as it is about pursuing new technologies. **PM**

Reporting by Joe Pappalardo, Barbara S. Peterson and Jeff Wise



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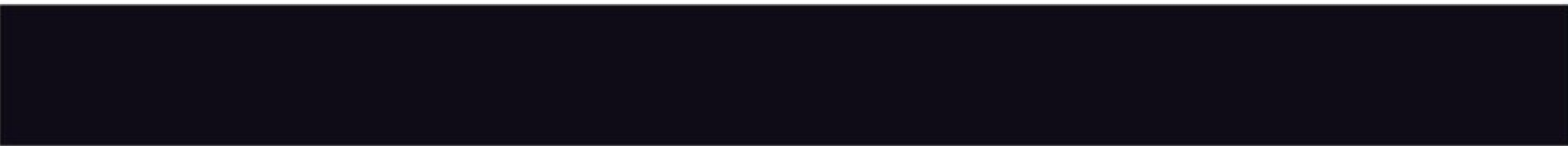
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THICK BLACK SMOKE RISES FROM A COMPOUND IN ABBOTTABAD, PAKISTAN. STUNNED NEIGHBORS MILL AROUND THE 10-FOOT-HIGH WALLS AS THE PAKISTANI MILITARY CORDONS OFF THE AREA. THE STILL-BURNING WRECKAGE OF A U.S. AIRCRAFT LITTERS THE COMPOUND YARD. INSIDE THE BUILDING, FOUR CORPSES, SHOT DEAD, LIE IN CONGEALING BLOOD. ¶ IT'S MAY 2, AND THE WORLD IS LEARNING THAT OSAMA BIN LADEN IS DEAD, KILLED BY A U.S. SPECIAL-OPERATIONS UNIT DURING A NIGHTTIME AIR ASSAULT. THE RAIDERS SUFFERED NO CASU-

BEYOND BIN LADEN: THE NAVY SEALS' NEXT MISSIONS

ALTIES BUT CRASHED A HELICOPTER, WHICH THEY BLEW UP TO PRESERVE ITS SECRETS. **BULLETS, BODIES AND WELL-ORCHESTRATED CARNAGE: THE NAVY SEALS WERE HERE.** ¶ SEALS (THE ACRONYM STANDS FOR “SEA, AIR AND LAND”) WERE LEGENDARY WARRIORS LONG BEFORE THE BIN LADEN RAID. FORMED BY PRESIDENT JOHN F. KENNEDY IN 1962, THE SEALS OPERATE IN EVERY ENVIRONMENT IMAGINABLE TO REACH INACCESSIBLE PLACES, COLLECT BATTLEFIELD INTELLIGENCE, ATTACK HIGH-VALUE TARGETS AND TRAIN FOREIGN

troops. Pentagon officials have relied heavily on these units during the decades-long global campaign against terrorist organizations. When Special Operations Command (SOCOM) recruits personnel for the secretive Naval Special Warfare Development Group, aka Team 6, the unit that killed bin Laden, it looks only at SEALs. After President Barack Obama met the team that raided bin Laden's compound, he called them “the finest small fighting force in the history of the world.”

At the start of their careers, before a life of training and experience, SEALs are able to swim 500 yards in 8 minutes and crunch 100 sit-ups in 2 minutes; most are expert assault-rifle marksmen. These days they spend more training hours on “special reconnaissance,” operating silently close to the enemy, than on traditional underwater demolition

skills. This work demands specialized gear, including clandestine vehicles, surveillance robots and human-target tracking technology.

As the SEALs celebrate the mission in Pakistan, they are also looking to the future. Their next-generation gear foretells how the SEALs will conduct upcoming secret missions—by sea, air and land.

1. SEA

focused on two sizes of dry combat submarines that will do much of what was envisioned for the ASDS. "It won't be as big as the ASDS, but the speed, range and duration should be close," says Rear Adm. Edward Winters, commander of Naval Special Warfare Command, which is responsible for equipping the SEALs. The smaller version may be tested in 2014, according to budget documents. These vehicles will be used for traditional SEAL activities such as sabotaging ships and disabling antiship mines. Current wars against low-tech insurgents are not typically fought on the ocean, but African piracy and the growing navies of China and Iran may focus attention on such missions.

SOCOM is also pursuing new surface vessels to deliver SEALs to a mission. In the next few years, the Navy's Special Warfare crewmen are expected to field Combatant Craft, Medium (CCM). The boat will replace the aged Naval Special Warfare Rigid Hull Inflatable Boat, and a heavier version will replace the Mark V Special Operations Craft. "The secret is being able to meet the payload requirements and still make the necessary speed," says C.J. Lozano, the director of government products for Willard Marine, one company vying for the contract.

The Navy hasn't released many details, but the CCM will likely have design elements more common to jet fighters than to boats: a low radar profile, a head-up display with synthetic vision, a light-

THE LATE-AFTERNOON SUN LINGERS ON THE HORIZON AS A WHITE FORD F-350 PULLS OUT OF A NAVAL TRAINING FACILITY IN PANAMA CITY BEACH, FLA. TWO PLAINCLOTHES SEALs IN THE CAB ARE HAULING A 21-FOOT-LONG TUBE, HIDDEN UNDER TIGHTLY TIED GREEN CANVAS.

The SEALs and their top-secret cargo, the Mk8 Mod1 SEAL Delivery Vehicle (SDV), are headed to a Coast Guard boat ramp across the harbor. The SEALs will tell any curious gawkers that they are a crew from the Discovery Channel, filming underwater. In reality, they are here to meet trainees to teach them how to operate the submersible, which is deployed from a pod mounted on the hull of a full-size submarine. Of the approximately 2600 active-duty SEALs, only about 230 are qualified for SDV missions.

It's hard duty—the SDV is a "wet" sub, meaning the vessel is operated while flooded, with pilots and passengers wearing scuba gear. There are no windows, no windshield. Navigation is performed with sonar or, on the surface, GPS. "Picture a 55-gallon trash can. Fill it full of ice water. Put an Xbox in there. Climb in and put the lid on, then stay for 12 hours," says veteran SEAL Daniel Jacob, leading chief petty officer at the Naval Special Warfare Advanced Training Command Detachment in Panama City. "It's cramped and cold, and until you beat the game, that's where you're staying."

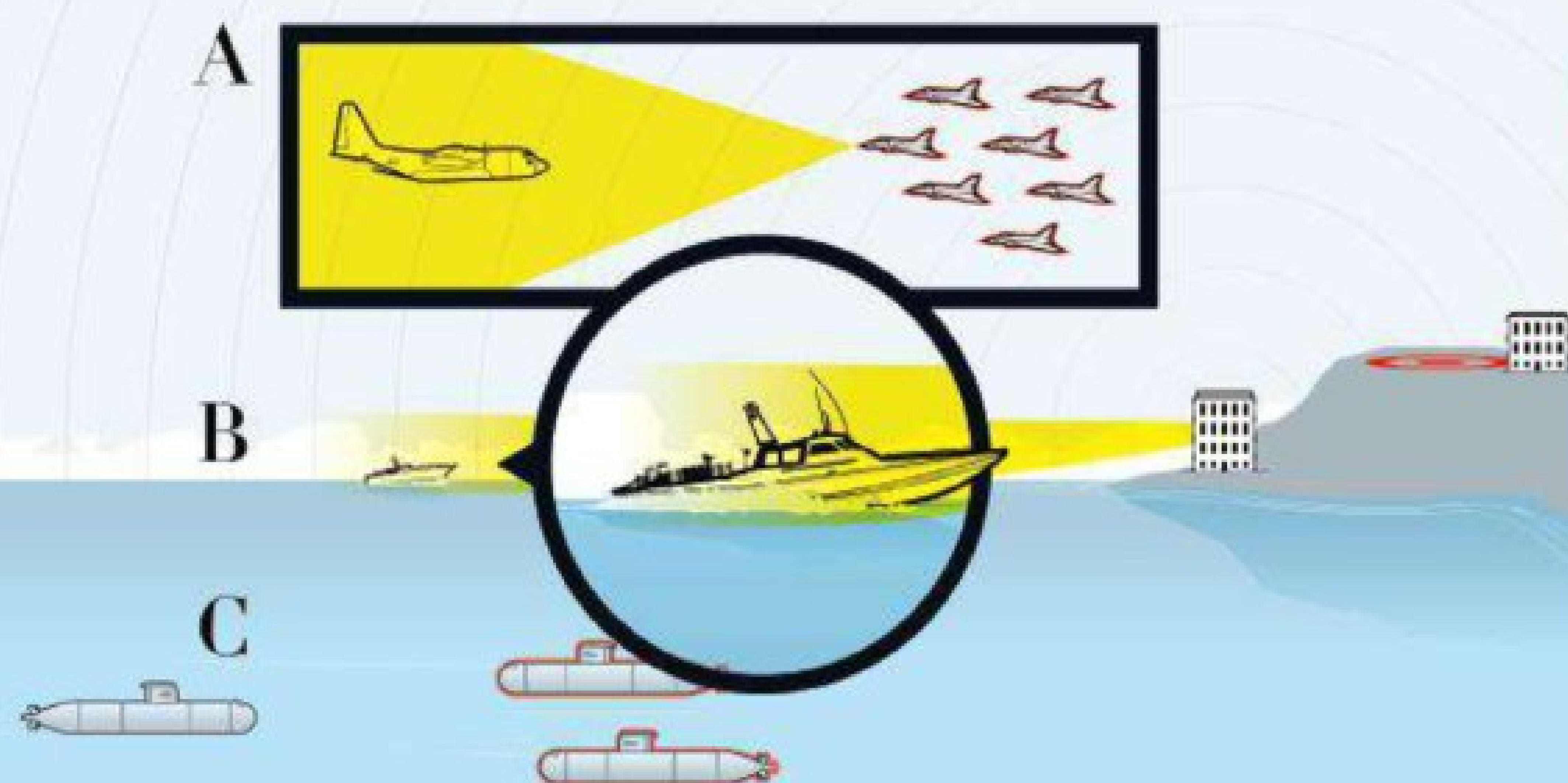
The SEALs know better than anyone that the Mk8 Mod1, an improved model of a 1976 original, is outdated, even with its upgraded electronics and navigation systems. SOCOM has been working on a replacement for 17 years; the proposed 65-foot Advanced SEAL Delivery System (ASDS) would carry at least 10 men in dry, pressurized comfort. SEALs in scuba gear would slide out of the hatch when it was time for their mission.

In 2008, when a lithium-ion-battery fire destroyed the only ASDS prototype, SOCOM decided not to repair the minisub. But a new program is under way,

CONCEPTUAL OPERATION: BLACK SURF

Mission: Plant surveillance equipment near a weapons depot on a well-guarded shore.

Challenge: Many potential foes have high-tech sensors on land and sea to stop such incursions. "You're talking about an environment today where it's harder to sneak up on anybody's coast," says Rear Adm. Edward Winters, commander of Naval Special Warfare Command.



INGRESS OPTIONS

(A) PARADROP

Powerful radar on shore and modern warplanes make dropping SEALs from a cargo plane too dangerous.

(B) BOAT

Thermal sensors and surface radar make any approach by surface vessels too risky for a clandestine mission.

(C) SUBMARINE

SEALs on underwater scooters could deploy from subs, but shallow water and enemy sonar keep the big subs too far away from shore.

THE RIDE OF CHOICE

SEAL DELIVERY VEHICLE Deployed from a pod mounted on a full-size submarine, the SDV is quiet enough to avoid sonar. SEALs in scuba gear swim out of this "wet" submersible and head to land.

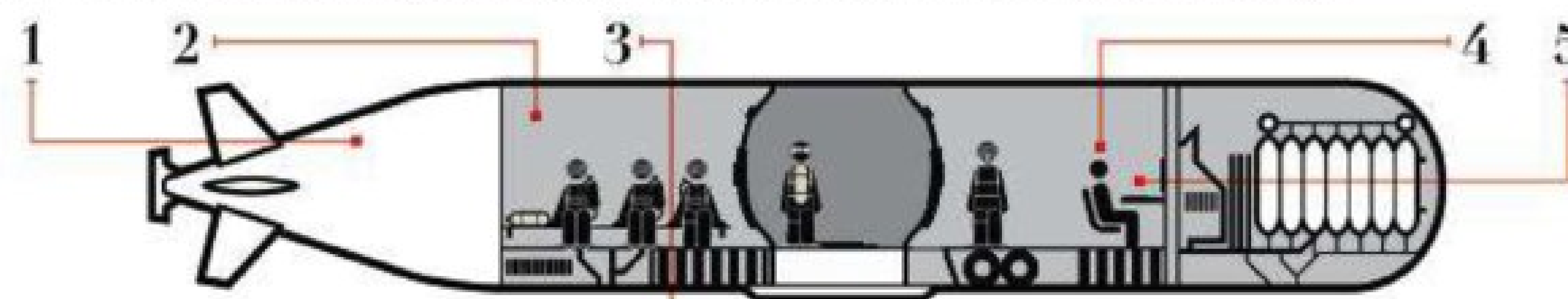


SDV SPECS (EST.)

Length: 21 feet Speed: 6 knots
Range: 70 miles Operators: Two
Passengers: Four

FUTURE TECH

SOCOM is working on three new underwater rides for the SEALs: a new short-range wet vehicle and two dry submarines for use on longer trips. Winters, who is responsible for procuring SEAL equipment, says his command is funding research into medium-size and small versions of the dry minisub; below are some features of a new dry minisub, based on public military documents.



(1) Silver oxide-zinc batteries power an electric motor.

(2) A pressurized interior allows deep dives.

(3) Docks directly to a mother submarine for faster deployment. Today, it takes 12 hours to mount a pod on a mother-ship submarine.

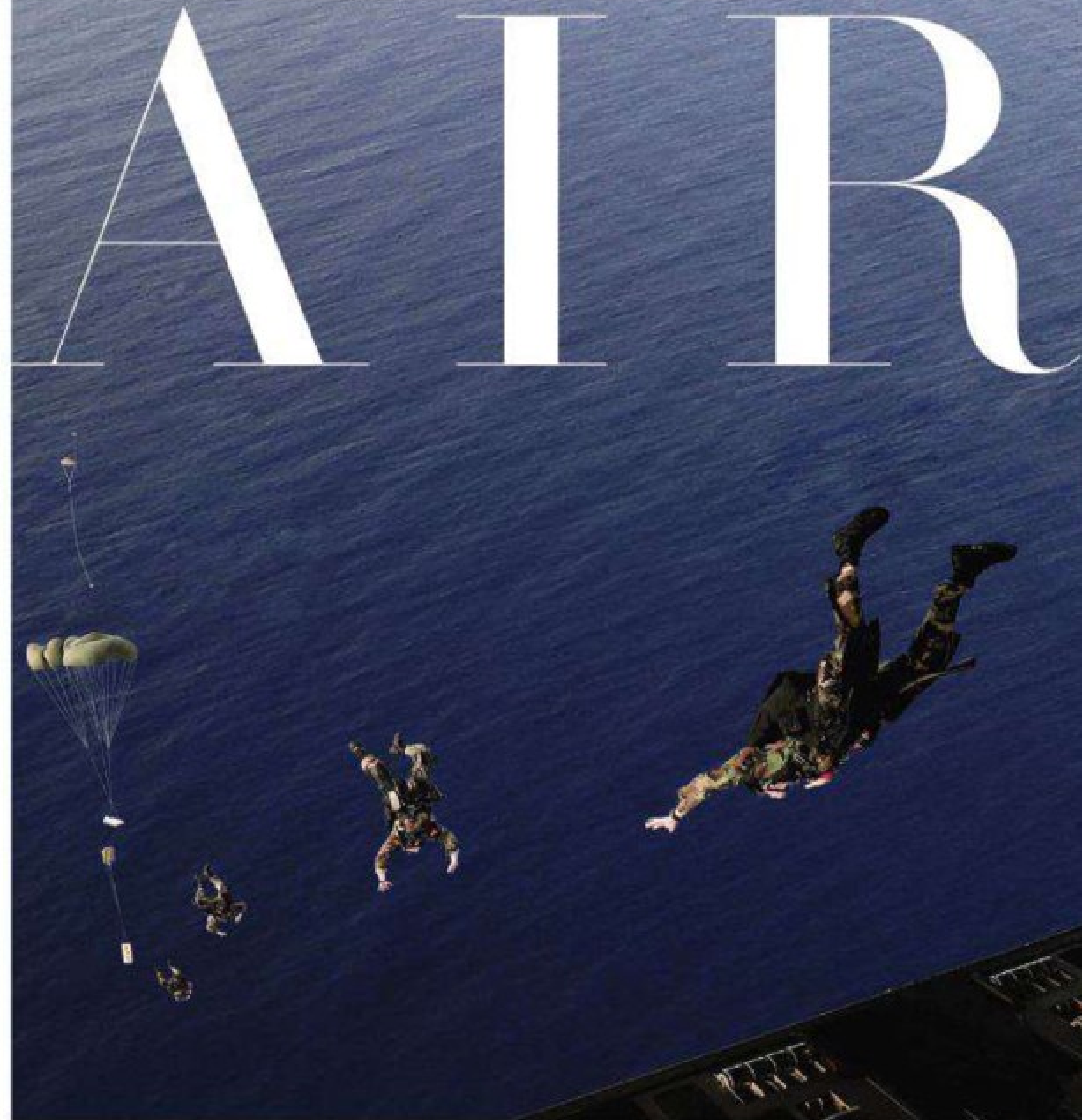
(4) Wireless, through-water communication with divers.

(5) Inertial navigation augments GPS.

weight carbon-fiber frame and intuitive drive-by-wire controls. (During a visit to Naval Amphibious Base, Little Creek, Va., in 2008, a PM editor steered a carbon-fiber testbed prototype using a simple joystick—no experience or training required.) And, as in aviation, naval special-operations planners see great potential in remotely operated vehicles. Mission planners could put robotic vessels above and below the surface into more dangerous situations for hours or even days, reshaping the SEALs' reconnaissance missions.

For now, SEALs have to make do with existing gear. At the Florida boat ramp, the SEALs wait for sundown to unwrap the Mk8, then gingerly back the trailer down a concrete ramp and slide the submersible into the water. Two novice pilots wearing dark wetsuits, masks and scuba tanks climb inside as the black hull hovers at the ramp's edge. The compartments fill with water, the men slide the canopy doors closed, and the vehicle sinks slowly beneath the inky, rippled surface. The goal of the evening is for the students to navigate under a nearby bridge, relying entirely on the sub's sonar. By midnight, they have not succeeded, and are shivering in their wetsuits. It becomes clear that the limitations of SDV missions are largely the limitations of the human bodies immersed inside. "Eventually you're going to get cold in any water colder than your body temperature," says Jacob, who won't reveal the details but says he has embarked on real missions in the SDV. "Your arms start failing, and your legs start failing, but your brain's still working. That's where you're eventually going to be." Or at least that's where SEALs will find themselves until the next-generation submersible is ready for action.

2.



Naval Special Warfare boat crewmen leap from a C-17; the craft and its pallet are already under chutes.

SEALS OPERATE AT NIGHT AND PREFER TO LEAVE NOTHING BEHIND THE NEXT DAY EXCEPT BODIES AND FOOTPRINTS. THE BURNING U.S. HELICOPTER IN THE YARD OF BIN LADEN'S COMPOUND WAS A VIOLATION OF THIS ETHOS.

The wrecked helo was a modified MH-60 Black Hawk, flown by the Army's 160th Special Operations Aviation Regiment. Navy SEALs have no aircraft, and must hitch rides with other military branches to fly to their missions. But on a clandestine operation of high importance, like the bin Laden raid, SEALs fly with the 160th SOAR, the Army's only designated special-operations aviation arm.

The SOAR helicopters used in Abbottabad were specialized, but the technology in them has been in development since the 1960s, when the Pentagon and the CIA hired the Hughes Tool Co. to create a helicopter dubbed The Quiet One. Hughes engineers knew rotor noise could be hushed by decreasing blade-vortex interaction, caused when a rotor slices through the small whirls of air created by the preceding blade. The Quiet One diminished this noise by adding an extra rotor blade so a pilot could slow the rotors, making less noise while remaining aloft.

CONCEPTUAL OPERATION: PLEASURE CRUISE

Mission: Rescue hostages from a liquid-natural-gas tanker hijacked at sea by terrorists. If the hijackers see a team coming, they will torch the ship and kill the hostages. **Challenge:** how to get a six-man SEAL team into action before the vessel reaches a port and probable self-destruction. The solution is to dispatch a team 20 miles from the tanker, at night, by parachuting the team and a Rigid Hull Inflatable Boat (RHIB) from a cargo transport aircraft.

(A) DROP THE BOAT

The 36-foot RHIB is attached to a platform and loaded in the back of a C-17 Globemaster III. At 5000 feet, over the designated area, the airplane's rear ramp opens. A 25-foot-wide extraction parachute yanks the platform from the aircraft, sliding it off the ramp. As soon as the RHIB is free, the boat separates from the platform.

(B) JUMP INTO ACTION

The SEALs and boat crewmen jump after the RHIB is clear, opening their chutes almost immediately. They fall in close formation—the first one out of the plane steers toward the target, and the other jumpers follow.

(C) FLOAT TO FIGHT

Four 100-foot-wide cargo parachutes open above the RHIB. SEALs choose not to attach parachutes to the platform or inflate its airbags, allowing the platform to fall and sink without a trace.

(D) READY TO RIDE

When the RHIB hits the water, its parachutes separate automatically. The SEALs swim to their ride, board and haul in the chutes. The team proceeds to the tanker under cover of darkness. After the mission, helicopters extract the hostages and SEALs.

The tail boom on the helo that crashed in bin Laden's compound also had at least one extra rotor blade, for this same quieting effect. Aviation researchers are developing more complex ways to deaden the thumps of rotors. For example, Eurocopter makes double-swept blades with piezoelectric flaps that adjust as many as 40 times a second to compensate for blade-vortex interactions. (See Tech Watch, June 2010.)

SOCOM officials always seek ways to operate independently, for example by researching remotely operated helicopters that could carry Hellfire missiles or cargo. This year, however, SOCOM transferred its unmanned helicopters to the Army for more evaluation. If industry can supply a reliable unmanned helicopter, SOCOM will likely buy a small fleet for its operators, including the SEALs.

SEALs pioneered the use of hand-launched UAVs, such as the 4.2-pound Raven, which they outfitted with a target designator to direct airstrikes by F/A-18F warplanes. The state-of-the-art SEAL UAV is the 13-pound Puma AE, which can set down on land or water and has a camera that automatically tracks targets. A gimbal keeps the image steady by compensating for shaking in flight. SEALs no longer have to aim the camera; they just toss the Puma AE and designate a target.

The future of special-operation UAVs lies in small, autonomous aircraft disguised as birds or even insects. These will fly over or inside buildings to gather video. For example, SOCOM is now evaluating a bird-shaped UAV called Maveric. "It's super-quiet and nearly indistinguishable from a turkey vulture," says Jason Grzywna, a co-founder of Prioria Robotics, which builds Maveric. "You can fly it over somebody's head and they would never know it's there." Much like the SEALs themselves.



FUTURE TECH

Aerial boat insertions are going higher and faster, says Elek Puskas, chief executive officer of Airborne Systems, designer of the SEALs' boat-launch system. "They jump between 4000 and 5000 feet, but requirements [for future systems] anticipate the need to jump at 10,000 to 12,000 feet," he says. The aerodynamic forces on the boat and pallet will be higher, but the extra altitude will allow cargo planes to fly above threats to deliver the SEALs. GPS-guided parachutes are now commonly used in Afghanistan; their role in special-operations paradrops will enable cargo to travel farther on its own, allowing SEAL insertion and resupply at longer, safer ranges.

3 • LAND



Navy SEALs in Desert Patrol Vehicles were the first U.S. troops in Kuwait in 1991.

The SEALs have experienced this kind of fight before, in the Vietnam War. There, SEALs recruited by the CIA advised reconnaissance units that sometimes executed supporters of Viet Cong guerrillas—but the effort was plagued by misidentification. Winning hearts and minds is difficult when detaining innocent bystanders.

These days, targeting is a priority mission, backed by high technology. The SEALs carry sophisticated kits that would be more familiar to a police forensics expert than to a soldier: DNA swabs, digital fingerprint scanners and iris imagers. These instruments can provide a team with a match within minutes, if the subject has previously been fingerprinted.

But SEALs are most often used to find terrorist or insurgent leaders, dubbed high-value individuals, who typically have no prints or other biometrics on file. These targets require DNA for identification, but the Pentagon doesn't have a system for digitizing results of genetic scans performed in the field, as it does for fingerprints.

Instead, paper results are sent by courier to a properly equipped base to make a match. It took the Pentagon 4 hours to identify the bin Laden DNA collected by the SEALs—the fastest genetic identification it has ever performed, according to SOCOM. The ability to use digital DNA results to immediately verify

SINCE SEPT. 11, NAVY SEALs HAVE BECOME ELITE MANHUNTERS. THEY FIND, IDENTIFY AND TRACK INDIVIDUALS—PRIORITY WORK IN COUNTERINSURGENCY CAMPAIGNS IN IRAQ AND AFGHANISTAN, WHERE A SINGLE PERSON'S DEATH CAN BE THE GOAL OF MONTHS OF SURVEILLANCE. WHAT THE PENTAGON ONCE CALLED THE "GLOBAL WAR ON TERROR" IS A PERSONAL BUSINESS.

MAY 2011:

BIN LADEN RAID

Vice Adm. William McRaven, commander of the Joint Special Operations Command, planned the bin Laden raid. Fortunately, he wrote the book on such missions. In 1995, the former SEAL team commander published *Spec Ops: Case Studies in Special Operations Warfare*, an analysis of the eight greatest raids in modern military history. In it, he explores the principles that enabled the missions to succeed. So, how does the admiral's raid stack up against his own criteria?



5

SIMPLICITY: A DELICATE BALANCE

"If a plan is complex, it will require extraordinary security, and an overabundance of security hinders effective preparation," McRaven writes. The use of stealthy helicopters complicated the mission. There was likely no way for McRaven to fully vet the modified helicopters and keep them a secret. It's not known how much time the pilots had to adapt to the new ride, but we know McRaven identified the risk and mitigated it by assigning enough helicopters to the mission. When one crashed, the hunt for bin Laden still proceeded.

4

SURPRISE: STAYING AHEAD WHEN THEY KNOW YOU'RE COMING

Of all the principles of a spec-ops mission, McRaven says this one is the most exaggerated. "Many tacticians consider the principle of surprise to be the most important factor," he writes. "What good would it do to surprise the enemy, only to be ill-equipped to fight?" Even when an enemy is surprised, special-operations raids are conducted against fortified positions and forces that are expecting trouble: "[It's] like two boxers in a ring; each is prepared to parry the other fighter's punches, but even with preparation, punches are landed." During the bin Laden takedown, Pakistani radar operators also had to be caught unaware. The method: helicopters modified to fly undetected.

1

PURPOSE: KNOW WHY YOU'RE GOING

McRaven says that each member of a special-operations team must understand the mission and believe in its success. "The mission statement should be crafted to ensure that in the heat of battle, no matter what else happens, the individual soldier understands the primary objective," he writes. The bin Laden mission could not have been clearer: Take him, dead or alive. When their helicopter crashed inside the compound, the SEALs in it simply disembarked and swept the building to find their prey and finish the job.

2

REPETITION: THERE IS NO SUCH THING AS TOO MUCH PRACTICE

SEALs trained in a mockup of the compound; McRaven maintains that such training should be mandatory if time allows, even though the SEALs are well-honed masters of clearing rooms by force. Team 6 members on the bin Laden raid did not need a refresher course on small-unit tactics, but they studied every room, entryway and blind spot of the compound, and got used to working with their teammates. "The plan that sounded simple on paper must be put to the test," McRaven says of his case studies. "Invariably, when a certain aspect of an operation was not rehearsed, it failed during the actual mission."



Vice Adm. William McRaven, the last man on earth a terrorist wants planning a raid against his hideout.

3

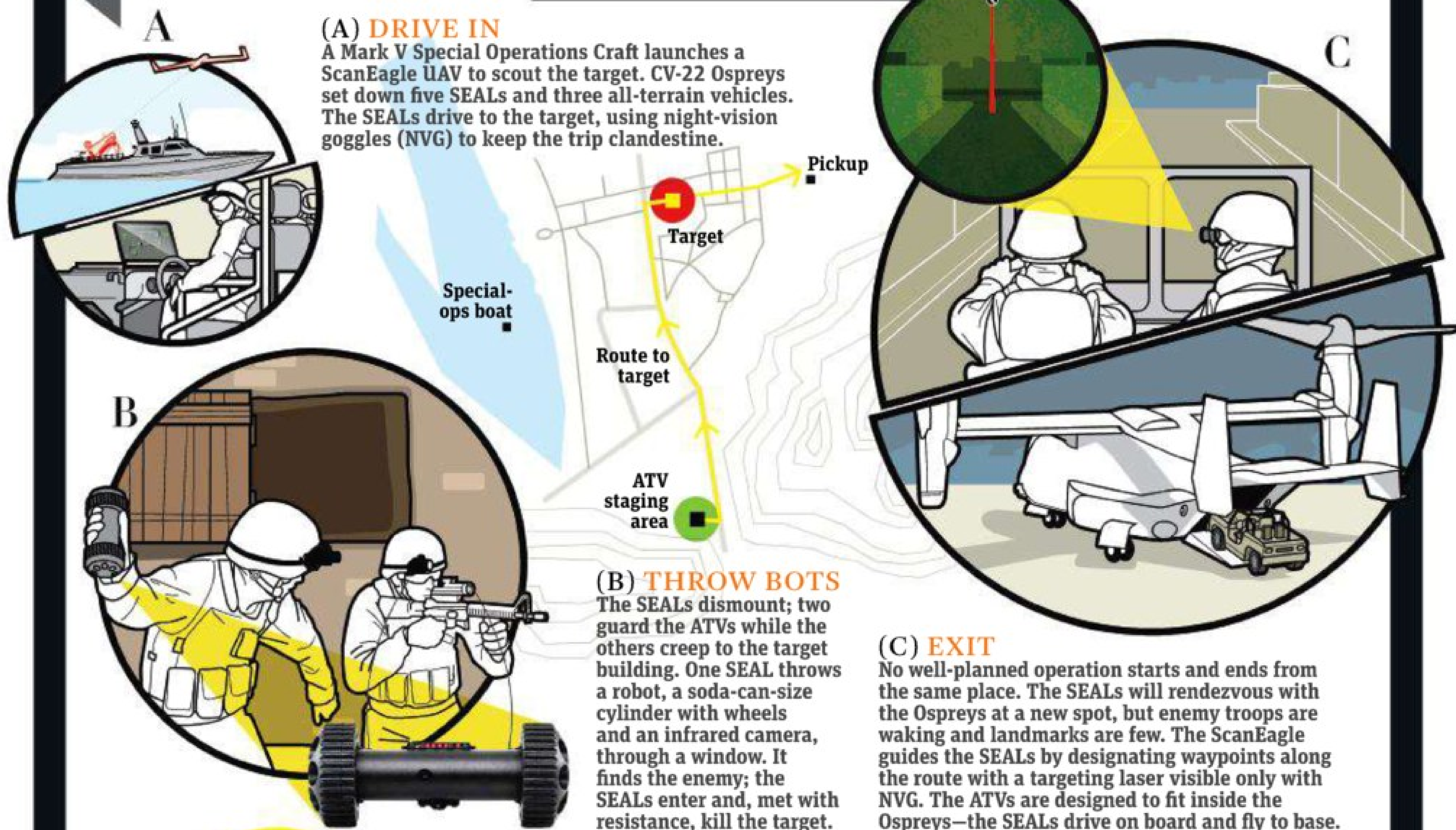
SPEED: DELAY FAVORS THE DEFENSE

"Most special operations involve direct and, in most cases, immediate contact with the enemy," McRaven says. Seven of his eight case studies took less than half an hour to complete—and the majority of the violence occurred within the first 5 minutes. The bin Laden raid took about 40 minutes, fitting this profile. The compound's defenders were overmatched, but the real risk was the potential reaction of the Pakistanis. The mission was also crafted to deny them time to respond.

CONCEPTUAL OPERATION: BAND LEADER

Mission: Kill or capture an insurgent leader in a remote village.

Challenge: Intelligence indicates the presence of shoulder-fired antiaircraft missiles in the compound, making a helicopter insertion too dangerous. The nocturnal mission depends on a quiet ingress and smooth exit to where U.S. aircraft are waiting, miles away.



FUTURE TECH

GOOD DIRECTIONS

ScanEagle is a combat-tested surveillance UAV equipped with day or night cameras. The Pentagon plans to rig UAVs with targeting beams visible to troops using NVG, as shown in the scenario above.

ROBOTIC SQUADMATE

The Navy is working on a new throw-bot with magnetized wheels that can climb metal walls and hulls. Manufacturer ReconRobotics is also building a mobile “marsupial” system to launch the robot.

identity could be crucial to a SEAL team that needs to exfiltrate as quickly as possible once it confirms the identity of its target—dead or alive.

High-value individuals often switch cars or use body doubles to throw off surveillance from agents on the ground and UAVs flying overhead. To counter this cat-and-mouse game, the SEALs employ taggants, tiny devices that emit electromagnetic signals. But how to persistently follow these signals? The answer might be nanosatellites. Earlier this year, SOCOM officials revealed last year’s launch of four satellites, each of which could fit in the palm of a hand, that can be used to track targets from orbit. They will not say whether the satellites are being used operationally. “We sent them up to demonstrate the exchange of tagging, tracking and locating data,” says Doug Richardson, a SOCOM official responsible for the program. “They worked.”

SEALs prize new equipment, but know it goes only so far. Vice Adm. William

McRaven, the commander who planned the bin Laden raid, states in his 1995 book on special operations that “the men must be inspired with a sense of personal dedication that knows no limitations . . . In an age of high technology we often overlook the need for personal involvement, but we do so at our own risk.”

McRaven knows that the SEALs’ most potent weapons, what makes them elite, are their brains and dedication. The rest are just tools. **PM**



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On the deck of the *Grandville Davis*, mate Dean West hauls in an experimental trawl. Fishermen hope this net, and others like it, will decrease bycatch—the capture of nontargeted marine life.



THE

WRONG

HAUL

THE ACCIDENTAL CAPTURE OF MARINE SPECIES KILLS MILLIONS OF FISH, BIRDS AND MAMMALS EACH YEAR. IT ALSO THREATENS TO CLOSE FISHERIES. USING HARD-WON KNOWLEDGE, FISHERMEN ARE REDESIGNING GEAR TO REDUCE BYCATCH, ENSURING THAT EVERY HAUL IS THE RIGHT ONE FOR THE OCEANS AND FOR PROFIT.

THE NETS COME OUT OF THE water like giant sopping drapes, 15-foot-tall cascades of blue and green mesh dripping seaweed. The wooden decks of the *Grandville Davis* shudder with the weight of tautog, scup, flounder, butterfish and hundreds of squid jetting streams of ink and seawater. The vessel's captain, Chris Brown, is dwarfed by the trawl. He wears the waterman's uniform: blue jeans, a sweatshirt and a ball cap grimed with fish scales. But he's unhappy with the catch.

"A shorter funnel might give the fish some time to think about a way out, give them more ways to escape," Brown says. The funnel is a tube of polyethylene mesh that channels fish caught by the net into a pound at the tail of the trawl. "Let's do a little engineering here." He stitches large folds of the mesh together with a needle the size of a ballpoint pen.

BY T. EDWARD NICKENS

PHOTOGRAPHS
BY JOÃO CANZIANI

"The more fish we can keep out of the net," he says, "the better."

This might seem like a curious comment for a commercial fisherman to make. But here in Block Island Sound, with Rhode Island a smudge in the west, Brown is not just fishing for squid. He's trawling for data and insights he can use to design squid nets that catch fewer fish, and thus help the squid industry navigate one of the thorniest issues fishermen face: the accidental capture of nontargeted species of fish, birds or marine mammals, called bycatch. While rates vary among fishing techniques, global totals of bycatch are in the millions of tons per year.

Today, the issue vexing Brown is a high incidence of scup and butterfish bycatch. By pulling an experimental net and a control net side by side 36 times over six days, Brown and a team of scientists and net-makers will test concepts for a new trawl designed to catch squid but make it easy for fish to escape. "The old paradigm for commercial fishermen is the hunting paradigm: Burn gas and find fish," Brown says. "But I want to be a harvester, not a hunter. I want a degree of certainty that I will catch fish. That means the fisheries have to be healthy."

Bycatch has a staggering effect on many species. In the Gulf of Mexico, an average of 4.5 pounds of fish—redfish, sea trout, flounder—and crab are caught for every pound of shrimp sold; most of that bycatch is discarded. Tuna and swordfish longlines set in the ocean can be 40 miles long and carry thousands of baited hooks; they kill enormous numbers of dolphin, sea turtles, sharks and seabirds. Migrating loons and red-breasted mergansers drown in nets set to catch flounder along the mid-Atlantic coast. Maine lobstermen struggle to keep their pot lines from entangling endangered Northern right whales. And all six species of sea turtles found in U.S. waters are vulnerable to fishing equipment.

IN THE GULF OF MEXICO, AN AVERAGE OF 4.5 POUNDS OF FISH AND CRAB ARE CAUGHT FOR EVERY POUND OF SHRIMP SOLD. MOST OF THAT BYCATCH IS DISCARDED.



MARINE LIFE ISN'T THE ONLY thing bycatch affects; it can also sink a fisherman's bottom line. Accidental entanglement costs time and money, and the bycatch of some endangered species can cause regulators to idle boats and shut down entire fisheries. That's why the World Wildlife Fund has attracted a growing number of fishermen to its International Smart Gear Competition, where they've used their experience to develop new equipment—from magnet-laden lines that repel sharks to trawls with escape

hatches that allow sea turtles to pass safely through. For sea turtles alone, the stakes are enormous: Between 1990 and 2008, experts estimate sea turtle bycatch losses of up to 8.5 million.

"There is fabulous innovation going on between commercial fishermen, agencies and nongovernmental organizations in a global push to reduce bycatch," says Ed Cassano, founder of Integrated Marine Education and Research Expeditions in Monterey, Calif. "The knowledge fishermen bring to the table



Capt. Chris Brown has outfitted the *Grandville Davis* with an experimental trawl, one engineered to catch squid but exclude scup and butterfish. "If we can find a way to be profitable and bring the oceans back to health—there's not a single fisherman out there opposed to that," Brown says.



NOTHING BUT NET

Bycatch, the accidental capture of marine life, endangers species and undermines fisheries. But new trawls exploit fish behavior to leave bycatch behind. — OLIVIA KOSKI

CURRENT METHOD

In bottom trawl fishing (above), boats drag weighted nets across the ocean floor. The simplest design is a giant net that funnels everything in its path into the cod end, where fish can't escape.

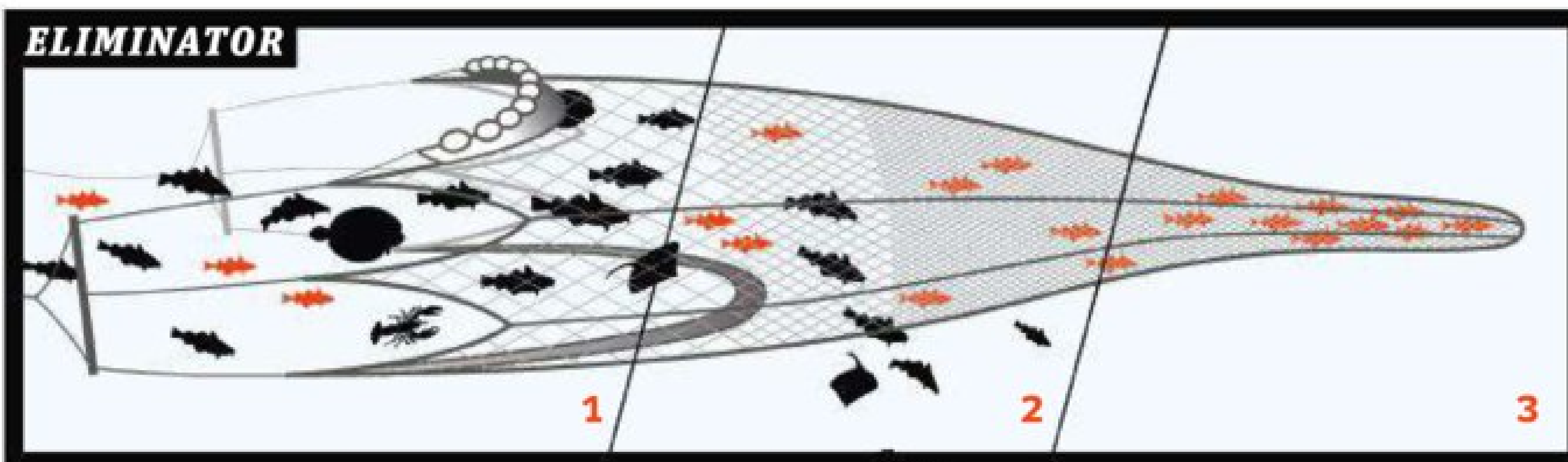
OTTER
BOARDS

HEADLINE

GROUND
ROPE

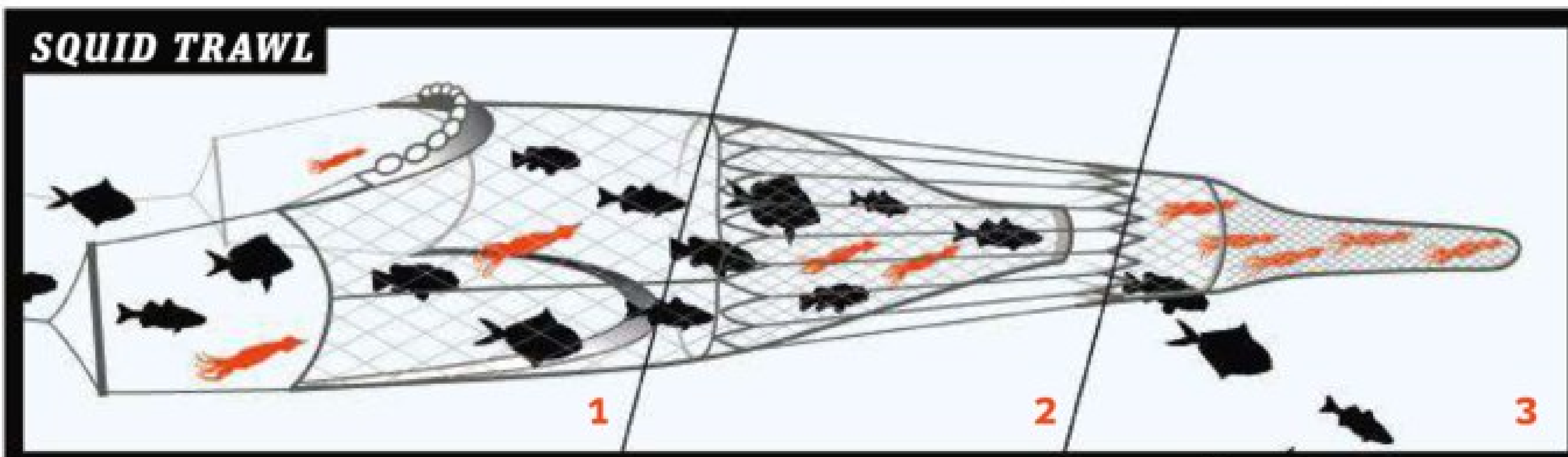
COD END

ELIMINATOR



- 1/ Lobster, flounder, haddock and cod enter the net.
- 2/ Lobster, flounder and cod head down, escaping from the net's large bottom mesh.
- 3/ Haddock swim up into the tightly woven cod end. Fishermen experiment with mesh size to maximize good haul and minimize bycatch.

SQUID TRAWL



- 1/ Bass, scup and squid enter the net, then swim into the funnel.
- 2/ Bass and scup emerge from the funnel and escape out the sides.
- 3/ Squid, weakened by releasing ink in the funnel, fall into the tail. Finding the funnel's sweet spot is key: too short, and all fish are lost; too long, and all catch goes in the tail end.

about gear efficiencies and fish behavior is irreplaceable.”

By exploiting how fish species respond to trawls, nets and lines, fishing gear can be fine-tuned to separate its catches. Modifications can be simple: In the '90s, about 16,000 seabirds such as petrels and albatrosses died each year in longlines set in Alaskan waters for sablefish, Pacific cod and turbot. In the nine years since fishermen began attaching brightly colored streamers to the lines, seabird deaths have dropped 70 percent.

Other bycatch-reduction methods are more technical. The Passive Porpoise Deterrent increases the “acoustic visibility” of gill nets, helping marine mammals avoid entanglement. When a porpoise

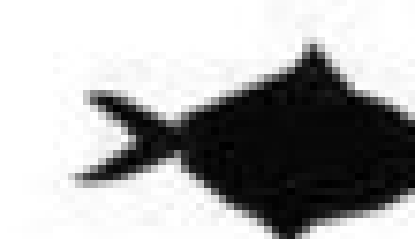
emits a click, resonant acoustic reflectors affixed to a net every 5 meters send an echo much bigger than the cetacean's largest prey. A small number of active pingers alert porpoises to the nets when they're not using echolocation.

Some technologies are a mix of *MythBusters*, high school shop class and advanced engineering. One is the Eliminator. When haddock encounter a net, they tend to swim upward, while cod and other fish head for the bottom. By designing a net with larger mesh openings near the rockhopper—the part of the trawl that drags on the seabed—the Eliminator traps haddock while allowing other fish to escape. The result: an 81 percent reduction in cod

bycatch and a 95 percent reduction in flounder bycatch, with little impact on haddock catches.

FINE-TUNING FISHING GEAR requires more than trial and error on a boat, however. On the concrete floor of a former clam- and fish-processing factory just yards from where Brown docks his trawler, Jon Knight uses a push-rod and fid to weave one polyethylene rope through the braids of another, splicing a reinforced rope eye into part of the Eliminator. Knight is the owner of Superior Trawl, and it's his job to turn ideas for gear into elaborately woven webs of mesh and

CONTINUED ON PAGE 111



HOMETOWN HEROES

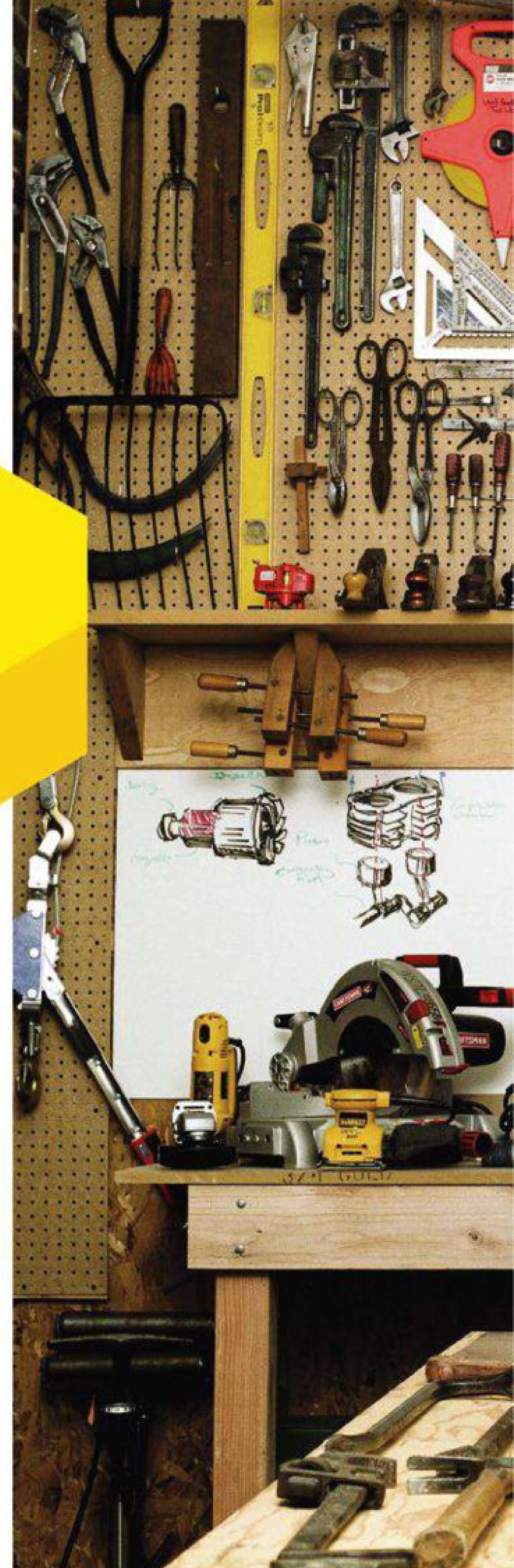
BY
AMANDA
DEMATTO

WAYS TO CHANGE THE WORLD (STARTING IN YOUR OWN BACKYARD)

BUILD A LOCAL TOOL LIBRARY

Patrick Dunn (right) and his buddies first discussed opening a tool library in October 2009. Like many good ideas, it caught on fast. Aided by a \$20,000 city grant and free use of an inventory-tracking computer system, the West Seattle Tool Library opened in June 2010. Today, it's a 220-member DIY center offering workshops and loaning from a stock of more than 1300 manual and power implements. The runaway favorite is the wood chipper. "People use it to turn brush into compost and mulch for their yards," Dunn says. With demand steadily increasing, he hopes to expand the library's collection with high-tech gadgets, such as a 3D printer, and "fun demolition stuff, like jackhammers."

"People come in wanting to build a chicken coop or a bat house," Patrick Dunn of the West Seattle Tool Library says. "The projects are random."



Chop Vines, Save Trees

It started as a way for Thatcher Drew, a digital strategist who spends long hours in front of his computer, to get

some exercise. The trees in a 12-mile stretch of parkland near his home in Bronxville, N.Y., were being choked to death by nonnative vines. So, one day in 1998, Drew waded into the thicket and started chopping. His friends and

family joined the effort, and over time the group gained county government backing. Today, the Vinecutters hold biweekly winter training sessions, and up to 300 volunteers fan out on

weekends to hack, chop and lop. With the vines in check, the trees, some more than 85 years old, are thriving. "It's a human-versus-nature drama," Drew says. "We can't let the vines take over the world."

You can volunteer to fight invasive species at the 540 national wildlife refuges scattered around the country (refugeassociation.org).



Turn an Abandoned House Into a Power House

While Detroit's population decline has grabbed headlines, a spirit of innovative community activism has quietly taken hold in Motor City. Mitch Cope and Gina Reichert, for example, have outfitted a foreclosed property near their own home with wind turbines and solar panels that power a heating system and efficient appliances. The couple plans to turn the house into an arts center and apartment for visiting artists. "We want to keep it off the grid and get enough solar [energy] and wind turbines to power this house and the house next door," Cope says. The aptly named Power House is proof that self-reliance and technological ingenuity can beat the odds—and build community.

Repair Old Bikes and Donate Them to the Needy



"I've been fixing bicycles all my life. I taught my kids to fix bicycles—it was just DIY experience we shared. About five years ago I started doing this, repairing bikes for 6, 7 hours a day and giving them away. I just take abandoned bikes, or ones I find in dumpsters, then get them into shape and donate them to charities like the Salvation Army. One day I was testing out a bike and saw a guy apparently hurrying to get to work. I asked him whether having a bicycle would help. He said, 'Certainly.' So I gave it to him on the spot. Last year, I gave away 138 bicycles. There's always a need. Ever since the GM plant closed here, in 2008, unemployment has been about 10 percent. I'll give someone a bike, and they'll use it to go on a job interview and then come back and tell me about it. That's very rewarding." — Tom Hillebrand, retired architectural designer, Janesville, Wis.



START A DIY SCIENCE LAB

BioCurious is part of a growing trend called biohacking, or garage biology. With \$30,000 in donations via kickstarter.com, housemates Eri Gentry and Joseph Jackson

founded BioCurious in their Mountain View, Calif., garage in 2009. They outfitted the space with equipment found on auction websites and collected from

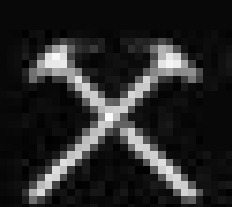
universities that were tossing used gear. From microscopes and beakers to an autoclave and a thermocycler, the lab took shape. Retired and amateur scientists flocked

there, paying to use equipment for various experiments: pathology to find a relative's cause of death, creating deer repellent—you name it. Having outgrown its old digs,

BioCurious moved in June to a nearby 2000-square-foot facility. Gentry and Jackson will rent space for as little as \$100 a month, keeping science within reach.

Kickstarter.com, indiegogo.com and other funding platforms are designed to help individuals raise money for projects.

"We've created a community facility where members can do science without paying a ton," BioCurious co-founder Joseph Jackson says.



Form a Home-Repair Collective

The first project that the Tampa, Fla., Home Improvement Team (HIT) tackled, 10 years ago, was a yard cleanup. "It was like the *Blair Witch Project* woods—overgrown and scary," HIT founder Maria Garcia-Gutierrez says. But a dozen volunteers transformed it into a lovely garden in one day. "Now we always think, just one day. You can build a mountain with 12 people in a day." That belief and other guiding principles—pool your tools, feed your workers, sign an injury waiver—have helped HIT become one of the most successful neighborhood-improvement collectives in the nation, painting houses, installing decks, refinishing floors, paving walkways, repairing porches and more.

PHOTOGRAPH BY DREW KELLY



Turn Derelict Land Into a Skate Park

The space beneath a city bridge can be a dumping ground and a magnet for crime and sketchy characters. The area under the Kingshighway Bridge in St. Louis was like that. But skateboarders Zac

DelCortivo and Kyle Crandall saw an opportunity there. They held fundraisers—a concert, an art show and more—to pay for materials (mainly framing lumber and concrete), and started building a monster DIY skate park. “The main bowl is huge,” Crandall says. “It took 30 yards of concrete to build

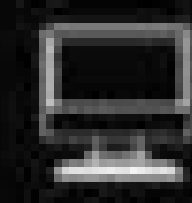
that part alone.” The entire park, started two years ago and now nearly complete, is the size of a football field. “We built an elaborate pyramid, spine ramps, a bunch of quarter pipes—it flows really nice,” he says. Today, with skaters almost always present, the sketchy characters have moved on.



BUILD A BUS SHELTER

“I don’t have any real carpentry experience; I taught myself. Last winter I put up three shelters where I’d seen kids catching the school bus, standing out in the elements. I got some of the materials from houses that were being knocked down. They all have benches. I put up flyers inside the shelters. One says, ‘You can be anything you want to be: governor, president . . .’ Another says, ‘You can be all of those things, but first brush your teeth and comb your hair.’ The kids thank me all the time. This summer, I want them to use ’em as lemonade stands.” — Omowali Lumumba, Carthage, Texas

Habitat for Humanity’s ReStores (habitat.org/restores) sell donated building supplies.



Build and Give Away Computers

After amassing parts via freecycle.org, Jordan Grant of Columbia, Mo. (below), began building computers. It started as a hobby, but soon he had too many computers on his hands. So, about a year ago, Grant began giving them to people of limited means, at a rate of two or three a month. A systems developer for Carfax, Grant is an Eagle Scout, an Army National Guard veteran who spent a year in Iraq and a man of conviction. “Personal investment in your community makes it a better place,” he says. “People ask why I give away computers. Well, that’s it.”



STOP DRUNK DRIVING



When it’s closing time in Louisville, Ky., inebriated patrons who don’t want to leave their cars at the curb call CityScoot. Mark Roberts founded the company with a cousin in 2004. Since then, CityScoot has ferried home 70,000 customers. After getting a call, an employee rides a scooter to the client’s car, folds it and slides it into the trunk, drives the client home and scoots back to HQ. Roberts just signed Captain Morgan as a sponsor, and the CityScoot model has been copied in other cities. “The ultimate goal for me was to start a business where I could make a difference,” he says. “We want to be there for people.”

CityScoot co-founder Mark Roberts (above center, arms crossed) and his crew make Louisville streets safer.

WHO’S YOUR HOMETOWN HERO? To nominate the person, people or organization making a difference in your backyard—and whom you’d like to see featured in PM—email popmechhero@hearst.com.



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Michigan's Silver Lake Sand Dunes are not normally host to three-row SUVs. But the shifting sands and towering hills proved the perfect locale for torture-testing these sometime off-roaders.



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WHERE THE PAVEMENT ENDS

*BETWEEN THE MINIVAN AND
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FAMILY HAULERS TO THE
TEST TO FIND OUT WHICH
ONE BEST BALANCES THE
REALITY OF ON-ROAD
CARPOOLING WITH THE DREAM
OF OFF-ROAD ADVENTURE.*

BY EZRA DYER
PHOTOGRAPH BY ASGER CARLSEN

OVER THE YEARS we've seen family transportation undergo a series of metamorphoses. The station wagon of the 1970s gave way to the minivan in the '80s, which was succeeded by the SUV in the '90s. At each step along the way, buyers were itching to rebel against the status quo and drive a machine untainted by connotations of parental dorkiness. If you really want to understand why the Ford Explorer became the smash-hit family car of the 1990s, look to the fact that there were no Explorers in the 1970s. The Ford SUV let grunge-era drivers buy a vehicle that didn't trigger childhood memories of 500-mile drives to Aunt Mildred's house for her slide shows of the Twine Ball Museum.

Now the SUV is itself the object of a generational backlash. And a lot of people who grew up in SUVs realize that they don't need low-range 4WD to get their kids to Dairy Queen, or a 10-mpg V8 to take the dogs to the park. Roughly a decade ago, three-row crossovers emerged, and the category has grown steadily since then.

Three-row crossovers attempt to fuse minivan practicality with SUV bravado. The formula is fairly consistent: V6, AWD with no low range, unibody construction and a high seating position. While SUVs are typically built on truck frames, crossovers are nearly always based on cars. The rationale is simple: People almost never use SUVs off-road, so why carry around all that gas-guzzling truck hardware?

And yet the implied justification for crossovers is that they deliver something that minivans can't: a capacity, however modest, for off-pavement adventure. To test these family drivers, we knew we had to include an off-road scenario that would bring the rugged-outdoorsman fantasy to life. Perhaps you never intend to drive a Kia Sorento up a five-story sand dune, but wouldn't you like to know that you could?

Our seven vehicles represent both the latest and the proven players from the U.S., South Korea and Japan. We spent three days wringing them out at the test track, on the interstate and back roads, and, finally, at Silver Lake Sand Dunes. Towering over the shores of Lake Michigan, Silver Lake offers a 450-acre off-road playground where drivers can test their vehicles' abilities on an undulating sea of sand that sucks down off-roaders like few surfaces do. In fact, deep sand is exceedingly challenging because it offers such high traction, taxing the ability of all-wheel-drive systems to reliably distribute torque to all four wheels. But, of course, a tough test was exactly the point. Here are our impressions in ascending order of desirability.

HONDA PILOT



STATS

Price: Base/
As tested ▶
\$41,175/\$41,175
Powertrain ▶
250 hp/253 lb-ft;
3.5-liter V6/5A
Wheelbase (in.) ▶
109.2
Length (in.) ▶ **190.9**
Curb weight (lb) ▶
4620
0–60 mph (sec) ▶
9.02
Quarter-mile
(sec/mph) ▶
16.80 @ 82.39
60–0 mph braking
(ft) ▶ **130.95**
Lane change (mph) ▶
48.70
EPA fuel economy
(city/hwy) ▶ **16/22**
PM fuel economy
(mpg) ▶ **19.79**

VERDICT

**THE ODYSSEY'S
ODD OFFSHOOT**



BACK IN 2002, Honda introduced its new Pilot, with a 3.5-liter 240-hp V6. Nine years later, it has a 3.5-liter V6 that makes . . . 250 hp. While power isn't necessarily the deciding factor when you're crossover shopping, the V6's modest output is representative of the Pilot's dated feel. The dashboard's center stack, for instance, appears to be inspired by an '80s boombox—the more buttons, slots and readouts, the better. (Do we really need a separate button to call up a DVD title?)

The Pilot's biggest problem, though, is its Billy Baldwin syndrome: It can't escape the shadow of its much more appealing sibling, the Odyssey. "There's no style or personality that sets this apart from the excellent Odyssey," wrote one tester. Functionally, the Pilot is an Odyssey with a better tow rating (4500 pounds versus 3500 pounds), worse gas mileage and a less versatile interior. The stubby shifter even pokes out of the dashboard, just like the Odyssey's—though in the Pilot, that shifter commands only five speeds. (The Odyssey is available with six.)

So the reason you'd buy a Pilot—other than for its image—is for its off-road ability. And the Pilot handled itself well out on the dunes, being one of the few vehicles that never got stuck. On the road, though, the Pilot's overwhelming vibe is indifference. The steering is numb, the ride is smooth, the V6 is quiet as long as you don't work it hard.

We like to think of Honda as the Japanese BMW—an engineering-driven company that knows how to infuse its products with a certain level of inspiration. But the Pilot needs a major dose of the pixie dust that used to enliven Honda's products. "This is the perfect focus-group car," read one logbook entry. "They checked all the boxes but forgot the most important one—fun."

TOYOTA HIGHLANDER



WITH THE KIA representing a bit of a hot mess as the Ke\$ha of the group, the Highlander is our Céline Dion: a low-key, mainstream hit, but one whose appeal many won't understand. Like the Honda, the Highlander is based on a

minivan. Despite a pop-culture disdain for minivans, last year the Sienna outsold the Highlander. Score one for aesthetic honesty.

The Highlander's performance profile is all over the place. In a straight line, it's a screamer, like the smaller RAV4. But

when it comes time to negotiate a corner, the Highlander morphs from a snarling beast into a bowl of warm oatmeal. "Corners like a small sailboat," wrote one driver. In our on-road test loop, corners that were enjoyable in the Mazda CX-9 were a scary chore

in the Highlander. It doesn't help that the stability-control off button doesn't fully defeat the system. Whether on or off, the Highlander's stability control is as invasive as Asian carp in the Illinois River—we couldn't spin the wheels and paddle up to the sand's

KIA SORENTO

THE KIA QUICKLY emerged as the hot rod of the group. That's not surprising given that the Sorento packs 276 hp and the least weight. The tradeoff is that it's also smaller than many of its competitors, and its third row is fit only for kids.

The Sorento feels like it's aimed at a younger demographic than some of the others. Besides offering a tidy size and lively performance, the Kia also wears the lowest price tag by a wide margin. But when you look around the interior, you can see where they saved some of that money. The leather on the steering wheel has a texture that conjures elderly lizards, and the faux-carbon-fiber dashboard trim recalls the laser background option from 1980s yearbook photos. The seat heaters have two settings: scalding and off. As one tester wrote early on, "You can see where Kia saved a grand or so, but I challenge anyone to find why this car is 10 grand cheaper than the rest."

We got a hint at the answer on the dunes. The Sorento was initially a blast out on the sand, with its defeatable traction control and ample power enabling it to ascend a dune that later thwarted an actual dune buggy. The Kia, like every vehicle here except the Durango, uses a simple clutch to send torque

rearward. The computer engages the clutch when it detects that the front wheels are spinning, which on the sand happens whenever you hit the gas. Over time this constant clutch cycling builds up heat, and to protect the clutch, the computer eventually stops engaging it. So after roosting around the dunes for a while, the Kia subsequently regressed to its front-wheel-drive roots and dug its nose into the sand, reminding us that many a crossover is bluffing when it comes to off-road prowess. Nonetheless, the Kia came across as our sportiest, most youthful vehicle. If you're not looking for a true seven-seater, there's a strong case for the rambunctious Kia.



STATS



VERDICT

THE HAPPY-GO-LUCKY GREENHORN



Price: Base/As tested ▶ **\$34,690/\$35,890**
 Powertrain ▶ **276 hp/248 lb-ft; 3.5-liter V6/6A**
 Wheelbase (in.) ▶ **106.3**
 Length (in.) ▶ **183.9**
 Curb weight (lb) ▶ **4125**
 0-60 mph (sec) ▶ **7.60**
 Quarter-mile (sec/mpg) ▶ **15.92 @ 89.99**
 60-0 mph braking (ft) ▶ **120.00**
 Lane change (mph) ▶ **43.43**
 EPA fuel economy (city/hwy) ▶ **19/25**
 PM fuel economy (mpg) ▶ **20.09**

surface, so the SUV felt constantly bogged down. We briefly fought the stability control for a few spins before we parked it for lack of enthusiasm.

When describing the Highlander, the word maturity kept coming up. "I found myself reflexively driving slower in the Highlander," read one logbook entry.

"You're as disconnected from the sensation of speed as you are in a jet at 37,000 feet." If you expect great accommodations for passengers, then you're in luck—it's quiet inside, with plush seats. If you expect much success out on the dunes, that's a different matter. The Highlander is like some other Toyota

products in that it feels aimed at people who don't care about cars—the enthusiast bases are covered by other vehicles. You want a serious off-roader, there's the 4Runner. If you want a sportier crossover, the RAV4. A van? The Sienna. Which leaves the Highlander exactly in the middle.



STATS



Price: Base/As tested ▶ **\$37,155/\$43,636**
 Powertrain ▶ **270 hp/248 lb-ft; 3.5-liter V6/5A**
 Wheelbase (in.) ▶ **109.8**
 Length (in.) ▶ **188.4**
 Curb weight (lb) ▶ **4609**
 0-60 mph (sec) ▶ **7.69**
 Quarter-mile (sec/mpg) ▶ **15.82 @ 86.71**
 60-0 mph braking (ft) ▶ **118.57**
 Lane change (mph) ▶ **46.57**
 EPA fuel economy (city/hwy) ▶ **17/22**
 PM fuel economy (mpg) ▶ **21.00**



VERDICT

AIMING FOR THE MIDDLE—AND HITTING IT

FORD EXPLORER LTD



THIS EXPLORER revolutionizes the Ford lineup more than it does the crossover genre in general. The latest Explorer ditches the old body-on-frame, V8-optional truck for a unibody front-wheel-drive architecture that's shared by most of its competition. The question then is, how does the Explorer distinguish itself in a sea of similar vehicles? The angle Ford embraced: fresh

technology. The Explorer's MyFord Touch infotainment system is the first thing you notice when you climb aboard. The center stack is dominated by a large LCD framed by an expanse of white plastic. There aren't many buttons, as most functions are controlled by touch and voice. The consensus on the system is that it looks great but would actually benefit from a few

CHEVY TRAVERSE LTZ



STATS

Price: Base/
As tested ▶
\$40,750/\$43,065
Powertrain ▶
288 hp/270 lb-ft;
3.6-liter V6/6A
Wheelbase (in.) ▶
118.9
Length (in.) ▶ **205.0**
Curb weight (lb) ▶
4983
0-60 mph (sec) ▶
8.44
Quarter-mile
(sec/mpg) ▶
16.32 @ 84.68
60-0 mph braking
(ft) ▶ **116.56**
Lane change (mph) ▶
50.73
EPA fuel economy
(city/hwy) ▶ **16/23**
PM fuel economy
(mpg) ▶ **17.87**

VERDICT

**A COMPELLING
CASE AGAINST
TRADITIONAL SUVs**



GM NO LONGER builds a minivan—at least not officially. But that's the de facto role of the Traverse, and thus the big Chevy is the crossover that best apes a minivan's functionality. There's open space between the second-row captain's chairs, so kids can head for the third row without flipping seats. The interior is gigantic, and the third-row seats are suitable for adults (notably, there's also usable cargo room when all the seats are up). Thanks to direct injection, the Chevy V6 trumps the Honda by 38 hp while also squeezing an extra mpg of EPA-combined fuel economy.

Our Traverse LTZ was nearly loaded, but it lacked a navigation system. With portable GPS units available for less than \$100, that's how we'd want it. But the Chevy's still got a backup camera cleverly packaged in the rearview mirror. Nice solution.

While the Chevy scores hardware points, the execution is sometimes rough around the edges. The engine emits a hoarse growl. The interior plastics are rendered in agreeable colors but are sometimes of unfortunate quality. And the chunky, kicked-up C-pillar and narrow rear window sacrifice visibility for the sake of styling. You'll be looking sharp until you merge into a semi hiding in your blind spot.

Out on the sand, the Chevy was a pleasant surprise, its high-end power and 20-inch paws allowing it to climb the dunes without us worrying about getting stuck—at least until the all-wheel drive quit. The fantasy of the Traverse as an off-roader was dashed the moment the front tires clawed themselves into a hole, the front end sinking into the sand like an ostrich burying its head. Maybe it was embarrassed. After a suitable cool-down, the Traverse made it out of the park. We may have found its limits, but the Traverse is still better at playing SUV than the Tahoe is at playing minivan.

well-chosen buttons. One comment read, "MyFord Touch is love/hate. I love the bright, colorful screens and all you can do, but hate how slowly the touchscreen responds."

On the mechanical side, the V6 is tied for the group's most powerful, and benefits from a terrain response system that tailors the throttle response and all-wheel-drive

system to varying surfaces. On pavement, the Explorer generally received kudos for its ride, if not for its rather rubbery steering. Off-road, we expected the Explorer to run circles around the vehicles with lesser pretensions to adventure. The Ford, however, was our third crossover to have its all-wheel drive go AWOL on the dunes and required yet another digging

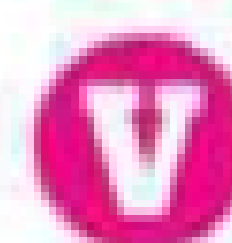
session to extricate it. As with the Kia and the Chevy, the rear wheels returned to action after a cool-off.

The new Explorer is handsome and likable, but it doesn't really blaze any new trails—at least not now. Once the turbo engines arrive—the four-cylinder and, perhaps, the V6—then it might push crossovers in a new direction.



STATS

Price: Base/As tested ▶ **\$39,995/\$45,710**
 Powertrain ▶ **290 hp/255 lb-ft; 3.5-liter V6/6A**
 Wheelbase (in.) ▶ **112.6**
 Length (in.) ▶ **197.1**
 Curb weight (lb) ▶ **4844**
 0–60 mph (sec) ▶ **8.43**
 Quarter-mile (sec/mpg) ▶ **16.28 @ 87.28**
 60–0 mph braking (ft) ▶ **118.32**
 Lane change (mph) ▶ **48.29**
 EPA fuel economy (city/hwy) ▶ **17/23**
 PM fuel economy (mpg) ▶ **19.01**



VERDICT

ONE OF THE MOST PROLIFIC SUVs RENOUNCES ITS PAST

MAZDA CX-9 GRAND TOURING

MAZDA'S CX-9 has a way of causing auto journalists to suddenly go inarticulate. Ask anyone who's driven the Mazda and he'll probably recommend it. Ask why and you'll get an answer along the lines of "I dunno. I just like it." The CX-9 can be hard to describe because its appeal isn't based on wild features or genre-busting specifications. Sometimes it just comes down to feel, and the CX-9 simply feels fantastic, from its skinny, communicative steering wheel to its carefully dampened ride motions. The CX-9 drives like a vehicle from a higher price sphere—something more in the realm of Audi and BMW. "Very much a car rather than a trucky SUV," wrote one tester.

You'd think that the CX-9's clear on-road bias would be a liability at Silver Lake, but the CX-9 never got stuck and never fried its all-wheel drive. The low front air dam did have an unfortunate scrape with the sand, but on the wide-open spaces the Mazda tore across the dunes with aplomb, its stability-control system stepping aside to allow some healthy rooster tails. If you ever got the urge to go camping out on some dunes,

the CX-9 could handle the assignment.

The CX-9 is now 4 years old, but it still looks fresh. Unlike the Traverse and the Highlander, the CX-9 is definitely driver-focused—the rear-seat setup didn't win much praise, but then the people back there didn't pay for the car, now did they? One tester asked, "Do the CX-9's sport-sedan leanings in terms of packaging and suspension tuning compromise the minivan duties too much?"

We'd say the answer is no. So with the best on-road prowess and an acceptable performance on the dunes, why didn't the CX-9 win? Because there's another vehicle that drags the SUV into the next decade in an entirely different way—one that ditches the traditional SUV compromises but maintains the credibility.



STATS



VERDICT

THE ONE CROSS-OVER THAT REALLY CARES ABOUT DRIVING



Price: Base/As tested ▶ **\$35,330/\$40,800**
 Powertrain ▶ **273 hp/270 lb-ft; 3.7-liter V6/6A**
 Wheelbase (in.) ▶ **113.2**
 Length (in.) ▶ **200.2**
 Curb weight (lb) ▶ **4568**
 0–60 mph (sec) ▶ **7.95**
 Quarter-mile (sec/mpg) ▶ **15.95 @ 87.15**
 60–0 mph braking (ft) ▶ **121.47**
 Lane change (mph) ▶ **49.55**
 EPA fuel economy (city/hwy) ▶ **16/22**
 PM fuel economy (mpg) ▶ **20.17**



PM'S TOP PICK

DODGE DURANGO



STATS

Price: Base/
As tested ▶
\$36,045/\$43,385
Powertrain ▶
290 hp/260 lb-ft;
3.6-liter V6/5A
Wheelbase (in.) ▶
119.8
Length (in.) ▶ **199.8**
Curb weight (lb) ▶
5117
0-60 mph (sec) ▶
9.26
Quarter-mile
(sec/mph) ▶
16.72 @ 85.79
60-0 mph braking
(ft) ▶ **124.07**
Lane change (mph) ▶
48.42
EPA fuel economy
(city/hwy) ▶ **16/22**
PM fuel economy
(mpg) ▶ **20.00**

 VERDICT

**THE BEST THREE-
ROW CROSSOVER IS
NOT A CROSSOVER**



Superficially, the V6 Durango looks a lot like all the other cars here: unibody, 290 hp, four-wheel independent suspension, 22 mpg on the highway. But there's a very important distinction. The Durango is not based on a front-drive sedan or minivan; rather, it traces its lineage to the Mercedes-Benz ML and GL SUVs (development started back when Mercedes still owned Chrysler). The Durango is thus a rear-wheel-drive platform, which has several happy consequences.

First, the Durango can tow more than any of the others—6200 pounds for the V6, and the V8 is good for 7400. (Oh, that's right—you can get a 360-hp V8.) And second, only the Durango has a robust differential—not simply a clutch—distributing torque front to rear.

The Durango enjoys the benefits of rear-wheel-drive proportions, with the front wheels pushed out to the corners and minimal overhang. "Exterior styling is spot on," read one logbook comment.

At Silver Lake Dunes, the Durango was unstoppable. It patrolled the sand with a tow strap permanently at the ready, since we quickly learned that the Dodge could tow other vehicles without getting stuck. It and a shovel brigade kept the rest of the troops moving.

Off-road heroism alone wouldn't crown a winner, but the Durango managed to deliver its old-school SUV chops without drawbacks. Its fuel economy and on-road handling were on a par with or better than the rest. And the interior, with rich materials and features such as adaptive cruise control and heated rear seats, certainly doesn't imply that it's a truck. The Durango feels like a blue-collar Mercedes. Which, essentially, it is.

The Durango has some weak spots, such as a five-speed transmission that will soon be replaced by an eight-speed. But as an overall package, nothing does a better job reconciling genuine ruggedness with daily usability. If crossovers represent a backlash against the SUV, then the Durango could spark a backlash against crossovers. **PM**

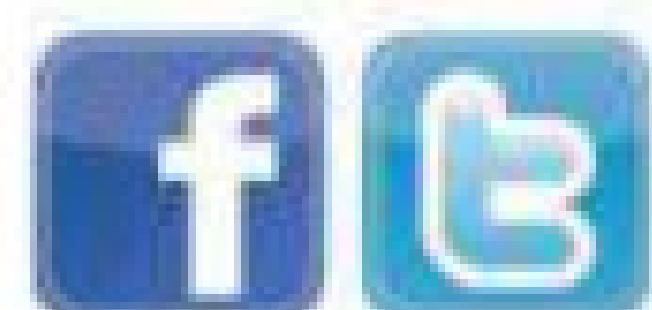
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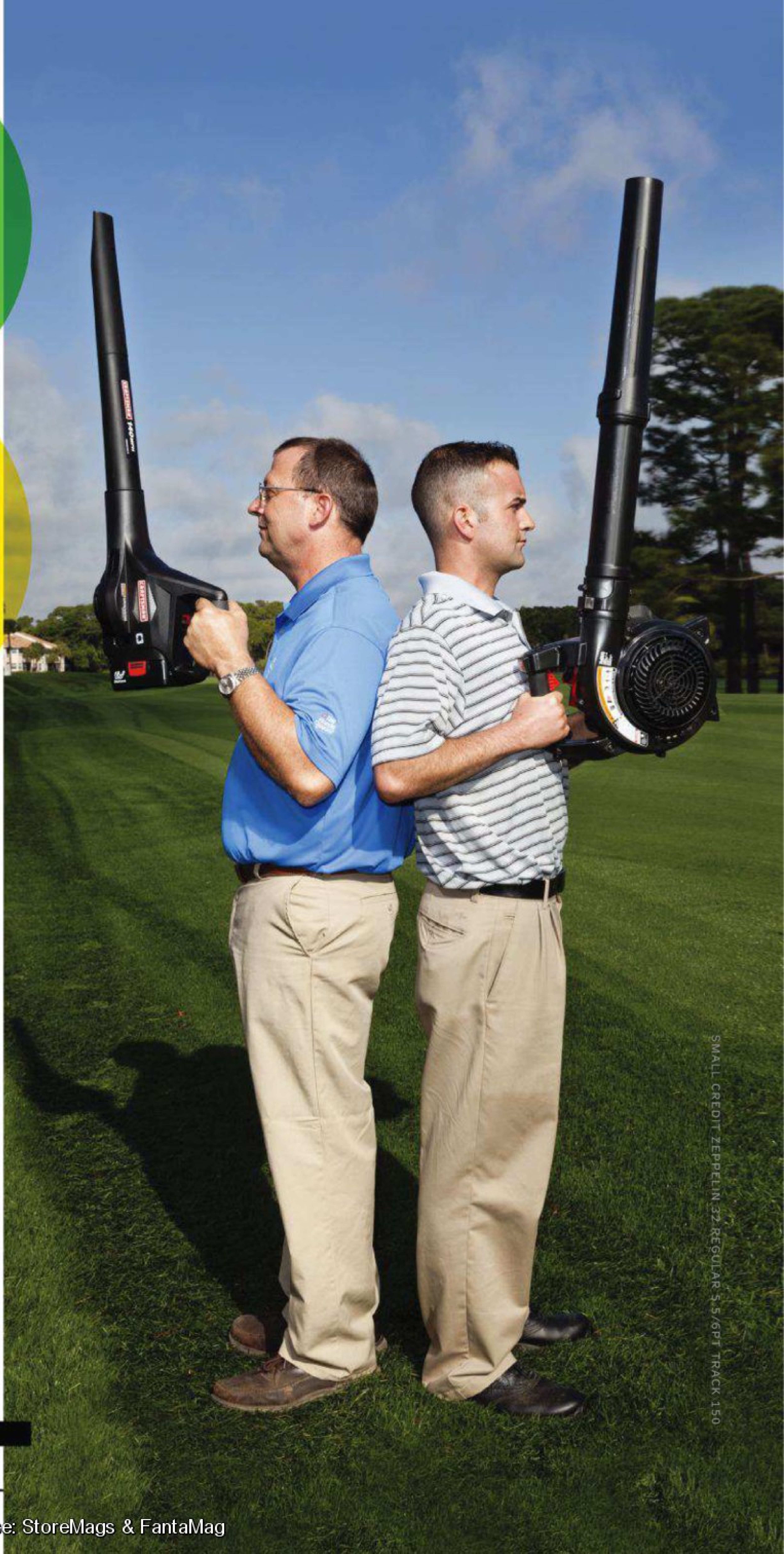
TURF

WARS

From muscle cars to lawn equipment, Americans have had a long love affair with all things high-powered. Indeed, there is a certain joy in clearing a leaf-covered yard with a blower driven by a snarling 27-cc, two-stroke gas engine. The exhaust fumes produced by that blower are another matter; the little engine is a big polluter. That may explain, in part, the rising popularity of yard tools with lithium-ion batteries. The tradeoff seems obvious: Electrics are quieter, cleaner and more environmentally friendly, but gas-powered tools get the job done faster because they're more powerful. We figured the best way to test the gas-versus-electric equation was to send two experts into battle—namely, two men charged with grooming a golf resort. By necessity, both rely on gas-powered tools. But one agreed to take up electric arms for our experiment. The results may surprise you.

By Evan Rothman

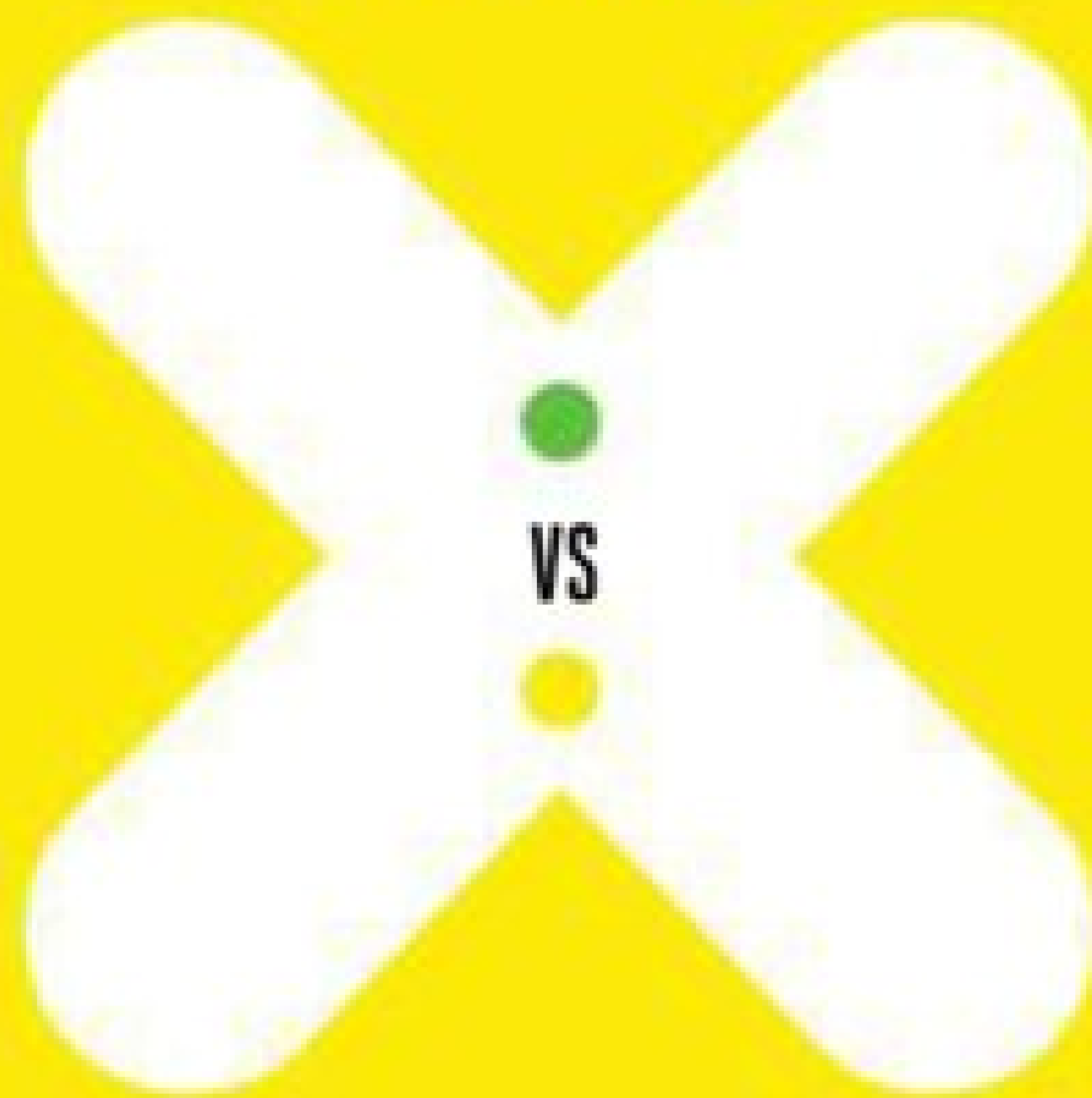
Photographs by Andrew Hetherington



SMALL CREDIT ZEPPELIN 32 REGULAR 5.5/6PT TRACK 150

The PGA National's wisecracking equipment director (far left) built his first engine at age 8. He commutes on an electric bike he made from spare parts. He believes electric tools are the future.

JOHN PATTERSON MR. ELECTRIC



MR. GAS BILL DIORIO

The superintendent of PGA National's Squire course has a turfgrass maintenance degree from Ohio State. "I saw some electric yard tools when I was growing up—mostly in the hands of little old ladies."

THE VENUE



We conducted our test on one of the largest, most meticulously maintained "yards" in the country, the 550-acre PGA National Resort and Spa in Palm Beach Gardens, Fla. A 90-person maintenance crew keeps five golf courses and the rest of the lush property in tiptop shape. All of the crew, including Patterson and Diorio, know a thing or two about using power equipment to keep lawns, hedges and edges neat.

BLOWERS



Troy-Bilt TB2SC

27-cc gas engine; airflow 150 mph/500 cfm; 9 pounds | \$150

Craftsman C3

19.2 volts; airflow 140 mph; 6.5 pounds | \$75

THE TEST

Push an approximately 2-square-foot pile of Bermuda grass clippings 62 feet along a concrete cart path.

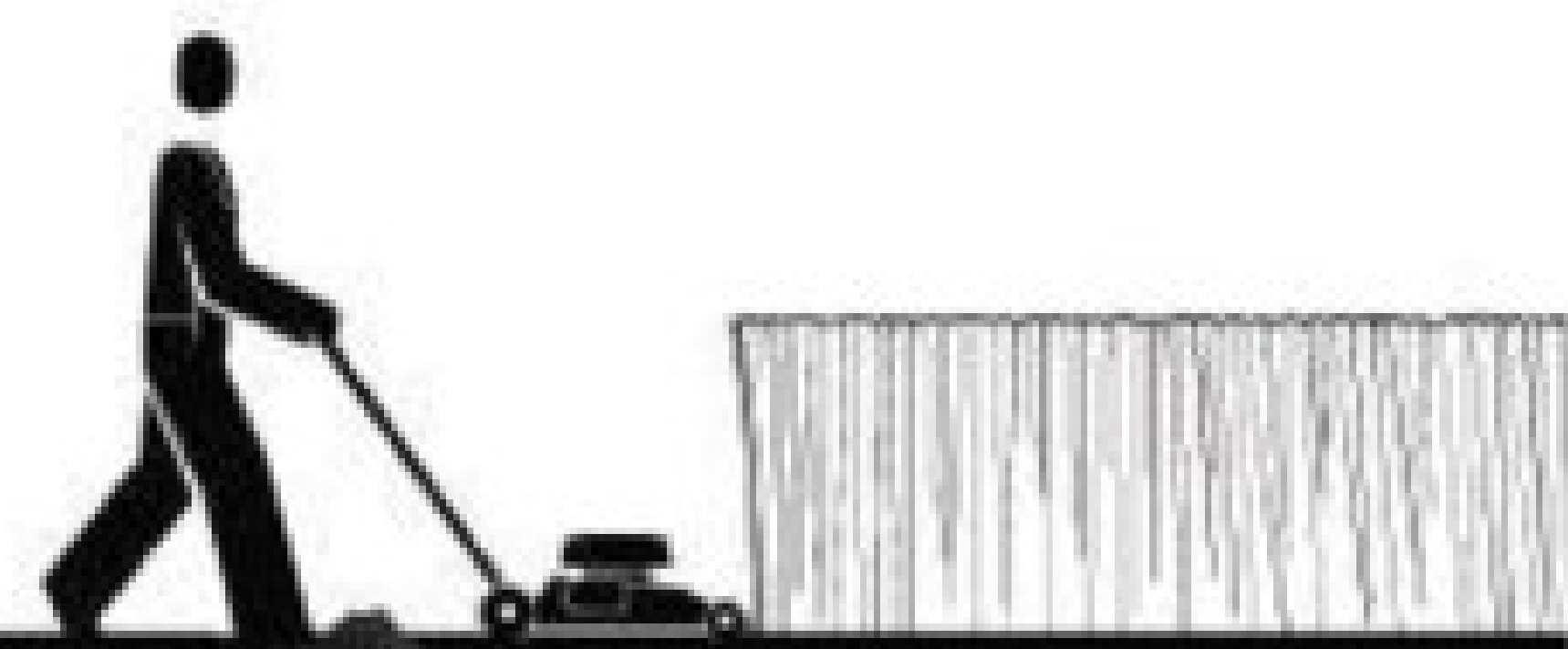


"I brought a knife to a gunfight," Mr. Electric says, clearly audible over his blower, which is as quiet as a hair dryer. He moves the pile across the finish line in 3 minutes and 25 seconds. After 2 minutes on full blast, the machine powers down a bit, because it probably wasn't fully charged, Mr. Electric believes. While the tool may not meet his professional needs, Mr. Electric says, "If you're going to do your driveway and maybe the walk, it's fine." Mr. Gas's chest swells while watching this display. His blower blows away the grass—and the competition—in just 56 seconds. Because of the round output nozzle, many clippings veer off to parts unknown. Mr. Gas cares not a bit: "It's about dispersion on the course, not control. Blowers aren't brooms."

PRO TIP

To avoid fatigue when using a gas blower, make use of both grips and switch hand positions often. Two hands are better than one.

MOWERS



Cub Cadet 11A-18M9010

139-cc OHV engine; 19-inch cut width | \$240

Worx IntelliCut Self-Propelled

36-volt motor; 19-inch cut width | \$500

THE TEST

Cut 159 linear feet of thick, unruly ryegrass from a height of about 7 inches down to a uniform 4 inches.



Ryegrass is to Florida—and all of the South, for that matter—as bluegrass is to the North: It's tough stuff. Mr. Gas gets all the performance he expects from his machine, even when catching the clippings and emptying the bag, a task he never performs on-course. Meanwhile, Mr. Electric is so pleased by his mower's performance in Power mode that he gears down to Quiet mode. "The blade runs a lot slower then, so you need to slow down, too," he says. "But it's still throwing the grass out of the deck and into the bag pretty good." Mr. Electric looks puzzled, then smiles with a realization: "Electric motors make the most torque at almost 0 rpm. So when that thing starts to bog down, it gets stronger, whereas a gas engine gets weaker." He knows engines—and motors.

PRO TIP

Sharpen blades frequently to reduce fuel usage and get a clean cut; grass frayed by a dull blade is more susceptible to disease.



Mr. Electric is breezing along, wielding the Stihl like a saber. "You could shave the back of your neck with this thing," he says. "The blade speed is good. This thing is amazing!" Meanwhile, Mr. Gas labors to control the more powerful and ungainly gas trimmer. After 6 minutes and 32 seconds of cutting, he's in a full Florida flop sweat. Mr. Electric takes pity on his adversary, and the men trade weapons. "Weight and balance are so important with these machines—you feel it in your shoulders quick," Mr. Electric says. Mr. Gas is also impressed by the electric: "I found it comparable in power and efficiency, though the gas tool got through the thicker branches more easily." The men agree that not having to breathe exhaust fumes at close range also gives the electric the edge.

THE TEST

Spend 10 minutes trimming the eugenia hedge—about 4½ feet tall and equally deep—that separates the driving range and the parking lot.

Husqvarna 122HD45

21.7-cc engine; 17¾-inch blade; 10.1 pounds | \$250

Stihl HSA 65 Cordless

36 volts; 20-inch blade; 10.6 pounds | \$400



HEDGE TRIMMERS



PRO TIP

Hedge trimmers demand careful handling. "You never see us working in shorts," Mr. Gas says. "Too many bad things can happen."

STRING TRIMMERS



Echo GT-225

21.2-cc engine; 16-inch cutting diameter; 10.6 pounds | \$160

Ryobi RY24201

24 volts; 13-inch cutting diameter; 6 pounds | \$160

THE TEST

Trim 86 linear feet of 3-inch Bermuda grass around fabric-skirted grandstands constructed for viewing the PGA Tour's Honda Classic.



Mr. Gas has trouble starting the machine. It sputters to life, runs for a few seconds and stops. After fixing the problem by relieving excess pressure in the gas tank, he finishes his run in just 6 minutes. But he's unhappy. Bottom line: The tool is loud (golfers turned and glared) and unwieldy, ill-suited for careful trimming around the grandstand's bunting. "There's almost too much power in the tool," Mr. Gas says. "Turning the corner, I got a little tired, my arms dropped, and I took a chunk out of the ground." Mr. Electric cut his swath in 8 minutes, at times holding the lightweight tool with one hand. While he felt the nimble electric provided precision, he still had a gripe: The trigger position and high pressure needed to depress it made his finger ache.

PRO TIP

When using a gas string trimmer, attach it to a supportive harness for greater control and less stress on your arms and back.



THE WINNER IS . . .

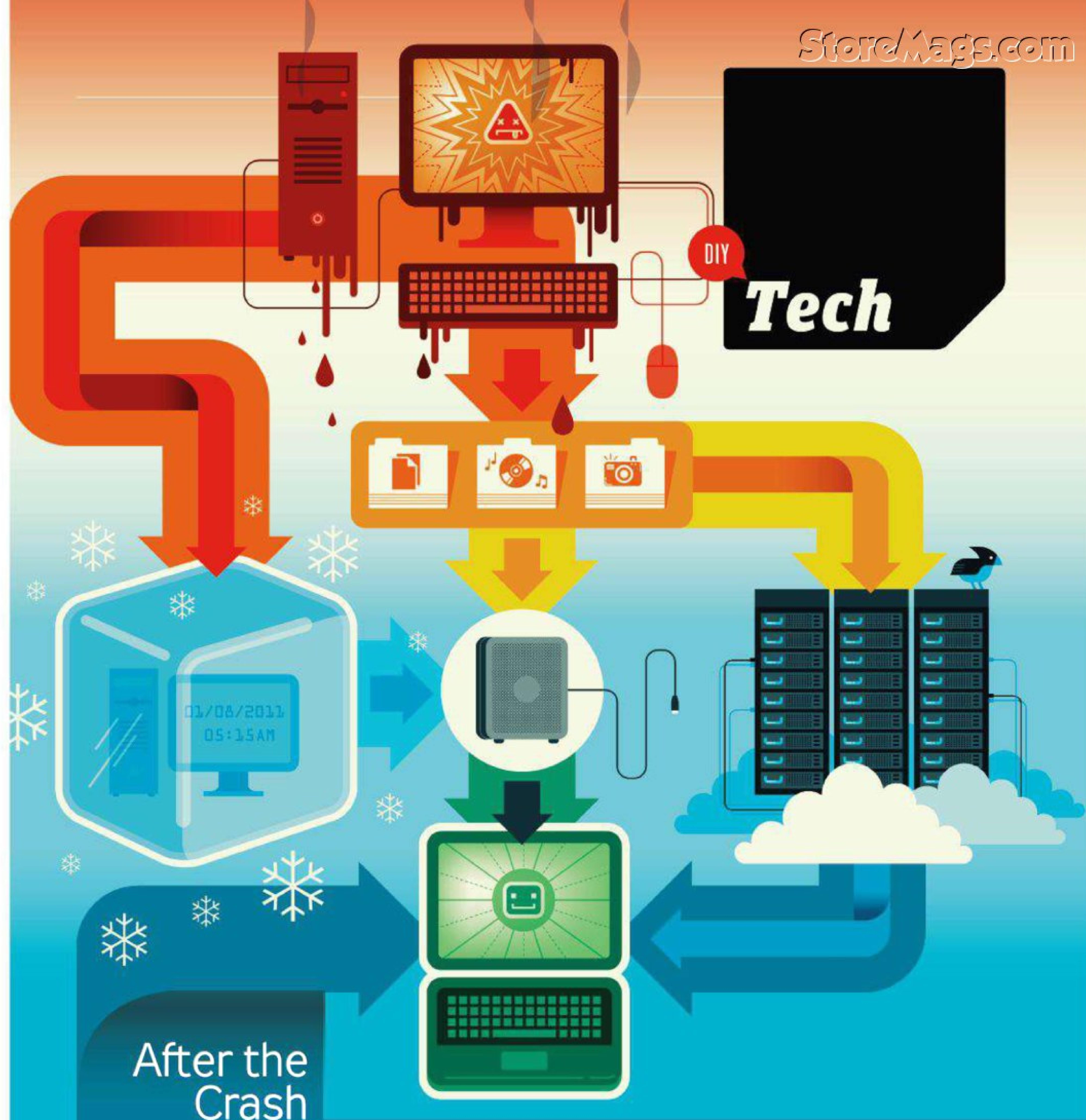
Mr. Gas and Mr. Electric, neither of whom had had prior experience with battery-powered equipment, were impressed by the performance of their electric yard tools. Mr. Gas calls the noise difference "huge," and both he and Mr. Electric agree that the tools seem powerful enough to suit many homeowners' needs. While neither man plans to go all-electric overnight, both can see the wiring on the wall. "I'm a believer now," Mr. Gas says, while Mr. Electric waxes on: "I was pleasantly surprised by the electrics, in particular by their power and the relatively light lithium batteries. Seeing the improvements in the battery and motor technology—electric is clearly coming. Even here on the golf course, electric could solve problems for us," including excessive noise and fuel costs. Plus, we suspect, he didn't mind winning.



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After the Crash

YOUR HARD DRIVE FAILED, BUT IT'S OKAY! YOU'VE BACKED UP YOUR SYSTEM. FIRST, PAUSE TO FEEL SMUG. NOW GET TO WORK RESTORING THE DATA.

BY GLENN DERENE

➔ **When my computer** wouldn't boot for the second time in one week, I knew the end was coming for the 4-year-old PC. It was hard to diagnose exactly what the problem was from its brief moments of lucidity—it could have been the hard drive failing, or the motherboard refusing to recognize the drive, or maybe something as simple as a corrupted file structure. It didn't really matter, though. My computer had become unreliable, and I was ready for a new one.

Best of all, I had been a good boy and backed up everything. How could I not?

DIY **Tech** RECOVERING FROM BACKUP

Like most technology journalists, I am constantly reminding my readers to back up their files—computers are inherently unreliable machines that are guaranteed to fail eventually, and the personal data we store on those machines is more extensive and valuable than ever. Plus, data backup is now built into both Microsoft Windows 7 and Apple’s Macintosh OS X operating systems, and most external hard drives and cloud storage services include their own backup software as well. After the initial backup process, any of these methods can be set to back up your data incrementally and automatically—the very definition of “set it and forget it.”

That is, of course, until you need it—the data, that is. And that’s the situation

I found myself in after I replaced my failed computer with a new one. I had a backup file. I knew where it was. The problem was, I wasn’t entirely sure what to do with it. That’s because restoring your data is not necessarily as clear-cut a process as backing it up in the first place. How you go about restoring your data depends on how you saved it, as well as how much you want to get back—and the results are not always what you might expect.

Only Files—or Everything?

➔ **Backup, in the general sense**, can mean two things: You can back up your files (saving folders of photos, music, videos, documents and emails), or you can back up your entire computer (creating a full bit-for-bit image of your hard drive frozen in time at the point of backup). For Windows Vista and Windows 7, both backup options are available in the Backup and Restore menu within the Control Panel. Apple has a time-coded incremental backup solution known as Time Machine built into OS X that does double duty, restoring files or system settings to a previous state (presumably before something went wrong), or recovering files and settings after a hardware failure.

Some third-party backup systems, such as Iomega’s QuikProtect, simply create and manage one-to-one file-level backups of your data. This is different from operating system backup programs, which typically create consolidated and compressed files that require the OS to unravel.

Whatever solution you use, however, I recommend backing up to an external USB or networked hard drive, or at least an online backup service. In the past, you could generally fit your backup on removable discs such as CDs or DVDs, but now the amount of data on modern computers and the frequency of backup render removable media completely inadequate. Invest in a real hard drive and you’ll make your life much easier later.

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The Glorious Restoration

➔ **How you backed up** your files will largely determine what you can expect to restore and what the process will look like. If you have just backed up your files and some basic settings for things such as your Internet browser, then you are going to have to do a little setup work to get your new or repaired computer functioning the way you like it. That means reinstalling all the software you know and love, then adjusting all the settings of each program until you are happy.

The process of getting back the files themselves is generally straightforward and automated. If you used Windows Backup and Restore, you can do this using the Control Panel under System



DON'T LOSE A LEVEL

BACK UP YOUR GAME SYSTEM, TOO

COMPUTERS AREN'T THE ONLY DEVICES THAT HOLD VULNERABLE, VALUABLE DATA. GAMING SYSTEMS HAVE LOTS OF HARD-EARNED GAME DATA, AS WELL AS PICTURES, MOVIES AND MUSIC. HERE'S HOW TO BACK UP AND RESTORE THE CONTENT ON YOUR XBOX 360 OR PLAYSTATION 3 HARD DRIVE. — STEVE ROUSSEAU

XBOX 360	BACK UP	RESTORE
	➔ Connect any USB storage device (we recommend a drive of at least 32 GB) to your console. Select My Xbox from the main menu, then Memory. From here you can transfer your data one item at a time, or you can dump everything with the Transfer Content feature.	➔ Once you've signed into your account, head to the Memory menu, select your backup drives, hit Y and then select the 360's hard drive as the destination device. Once the transfer is finished, the Dashboard will ask you if you want to renew your licenses—select Yes and you're done.
PLAYSTATION 3	BACK UP	RESTORE
	➔ Connect your USB storage device. Go to the Settings menu, then System Settings. Select the Backup Utility option, and then select Back Up. Annoying caveat: Downloaded content, such as games or movies, will not be backed up. These are linked to your PSN account and will have to be redownloaded upon restore.	➔ Simple as pie. Start the Backup Utility and select Restore.

THE BAD NEWS: Backup files between the two systems are incompatible, so if your 360 red-rings halfway through *Final Fantasy XIII*, you won't be able to pick it up on your PS3. Also, even though both systems have network connections, backing up to a network drive isn't possible. Each backup requires you to physically connect your storage device. And using the same drive for both systems will necessitate some partitioning—the PS3 and 360 use different file systems: FAT32 for the PS3, NTFS for the Xbox 360.

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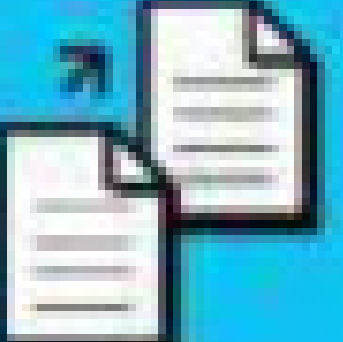
and Maintenance. Select Advanced Restore and then Restore Files Made on a Different Computer. With a clean copy of Windows, the system probably won't be aware of the backups you've made previously, so you may have to direct it to your external drive. The recovery tool discriminates and recovers data by user, so if your old computer or hard drive had multiple users, you'll need to decide which users' data to migrate over.

With third-party or online backup software, you usually just need to install the backup software first, then let it guide you through the steps to recover your backup. If you've just created your own file-level backup of your data, you can always find it yourself and drag the files and folders to your new hard drive.

Image Conscious

➔ **If you backed up** your entire system, the process is slightly more complicated, but if it's successful, you can expect to completely restore all of your software, settings and files exactly the way you had them when you last backed up. To restore a system image in Windows 7, you're going to need either your original Win 7 install disc or a system repair disc. (You can create one using the same Backup and Restore menu that you created the system image in.) When you boot from the disc, you get the option to Repair Your Computer and then select the system image and date you want to install. Be forewarned: If you just bought a new computer and you reimage its hard drive, you will erase not only the existing operating system but also everything the manufacturer installed in terms of software, drivers, etc. Of course, if you truly want to restore the environment of your old computer on your new one, erasing the data on the new computer is exactly the point.

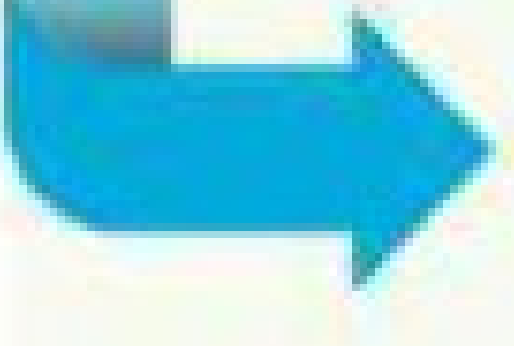
Once you give the go-ahead to reformat and reimage your drive, the process should continue on autopilot. Be prepared for snags, though: I made my first image-restore attempt from a network-attached storage (NAS) drive on my home network—and Windows

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CLOUD-BASED BACKUP



Backing up data to a local hard drive helps recover your files after a massive system failure, but it won't help if a fire, flood or tornado destroys your whole house. Big companies have known this for years, which is why most corporations have off-site backup to get them up and running fast in case of an emergency. Obviously, homeowners shouldn't need to set up dedicated remote servers to protect pictures of the family dog, but there are several cloud-based backup systems that, for a yearly fee, can back up your data to a password-protected online account and can also let you access your files from anywhere. — G.D.



Mozy is one of the more established services. For \$6 a month, you get 50 GB of storage; \$10 a month gets you 125 GB. Mozy's software installs on your PC or Mac, then automatically backs up your files in real time. **Carbonite** is similar but offers infinite storage for a single user for \$60 a year. For the low-volume user, **Jungle Disk** can offer a cheaper deal, charging \$2 a month for membership, then separate per-gigabyte fees for storage, uploading and downloading.

thought about my request for a moment, then totally ignored it. I got the process to work correctly only once I used another computer to transfer the file from the NAS to an external USB drive (I have a lot of extra hard drives lying around, one of the perks of being a tech journalist).

Windows 7 is pretty sophisticated, and if the image you're transferring is from a Win 7 system, then it will automatically start updating itself to the drivers necessary for the various connected USB devices, soundcards and graphics processors of your new machine. However, there are bound to be a few surprises. After my image restoration, I discovered that the 1-terabyte drive in my new machine suddenly thought it was the 500-gigabyte drive from my old machine. Fixing this required some careful noodling around in the Disk Manager utility to extend the partition and reveal the full 1 TB of disk capacity.

Apple's Time Machine makes this process considerably more user-friendly, building file and system migration into the setup process on a new Mac or after a new installation of OS X. Right after boot, the system will ask you if you already own a Mac, then give you the option of restoring from a Time Machine backup. Keep in mind, Time Machine backup works with any USB drive, but not all networked drives are supported.

Cross-platform data restoration is an entirely different animal. If you switch from PC to Mac or vice versa, most of your files can be moved over manually (provided they are in standard file formats such as .doc, .jpg, .mp3, etc.), but your software most definitely cannot. Some programs, such as Mozilla's Firefox, can be easily reinstalled, while other software, such as Microsoft Office and Adobe Photoshop, needs to be repurchased and reinstalled.

However you go about recovering your data, it's important to allow yourself plenty of time for the process. If, like me, you have hundreds of gigabytes of music, movies and photos, each step can take hours, and the entire recovery can consume a weekend. But even after I committed days to the process, my first step once I got all of my data back and organized was the same one that let me get back that data in the first place: I went to the Backup and Restore menu and set up my new computer for automated backup—because I'm a good boy.

PM

Digital Clinic

by Seth Porges

Q+A



Whatever Happened to Microprojectors?

A few years ago, techies were saying that microprojectors would change the world. Okay, so why don't any of my gadgets have them built in?

A Oh, yes, we remember microprojectors. They were an innovation that tech seers (like me) predicted would transform the way we use gadgets and share media. All the way back in 2008, when I got my first taste of what pico projectors (as the devices are often called) could do, I figured it was only a matter of time before the devices shrunk to a size that would make it possible to jam these babies into just about any gadget. Our phones would double as movie-playing projectors. Our laptops would project PowerPoint slides on the wall for instant presentations.

So why is it that today (an eternity later in tech time) your phone, tablet, laptop and GPS are all but certainly microprojector-free?

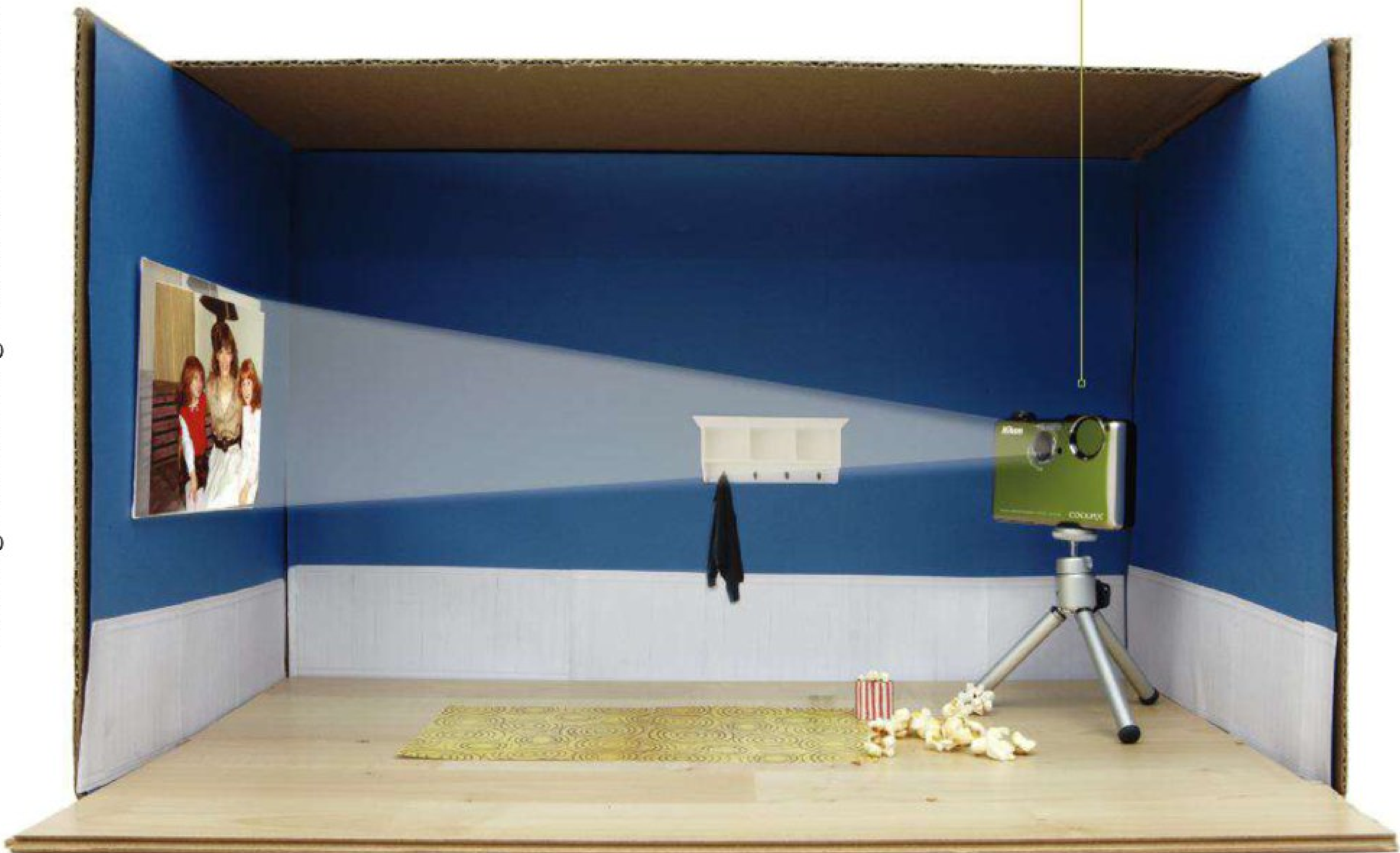
While it's easy to interpret this as a sign that tech companies have basically given up on the technology, the truth is that the inevitable march of microprojector prog-

ress has quietly been carrying on. Microprojectors may still take over the world—just a bit more slowly than we anticipated.

Here are some points of progress. Microprojectors are now capable of producing a 1280 x 800 HD image—something that would have been impossible when the projectors debuted. This resolution bump comes courtesy of the new Texas Instruments DLP Pico HD chip, which is being built into current or upcoming stand-alone projectors from Dell, Acer and Optoma. Microprojectors are also better than ever in bright environments. Early projectors required near-total darkness, but we've seen new models work in all sorts of well-lit rooms, with impressive results.

Of course, there's still the question of why our gadgets don't have projectors built into them. For sure, they can add a lot of wow factor, but manufacturers are reluctant to include a feature

Nikon's Coolpix S1100pj camera (\$300) has a built-in projector that allows you to instantly project a 47-inch image of your photos on the wall.



PHOTOGRAPH BY PHILIP FRIEDMAN

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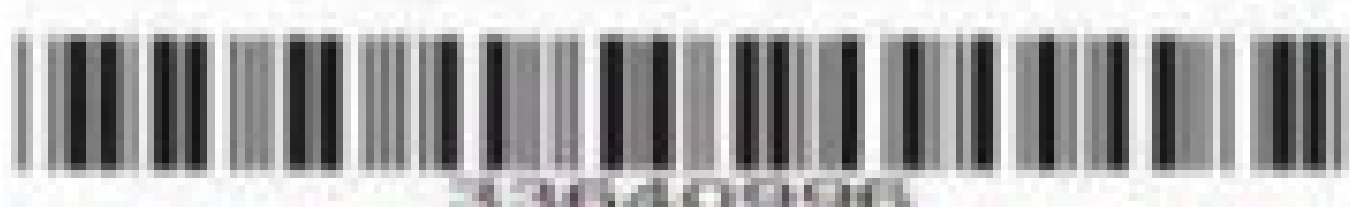
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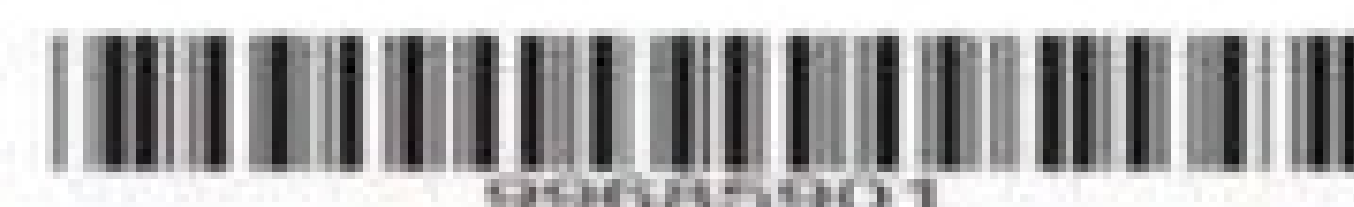
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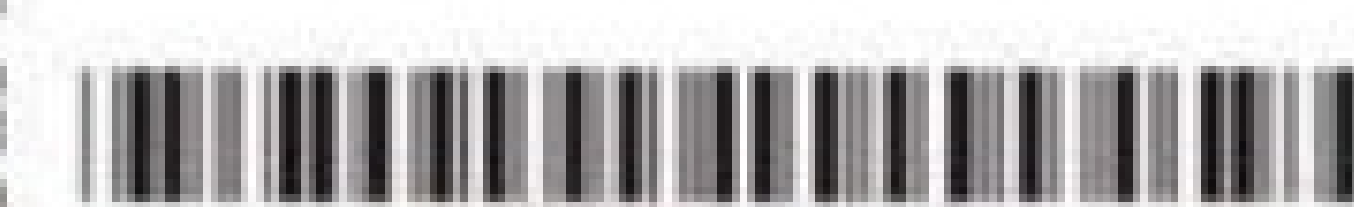
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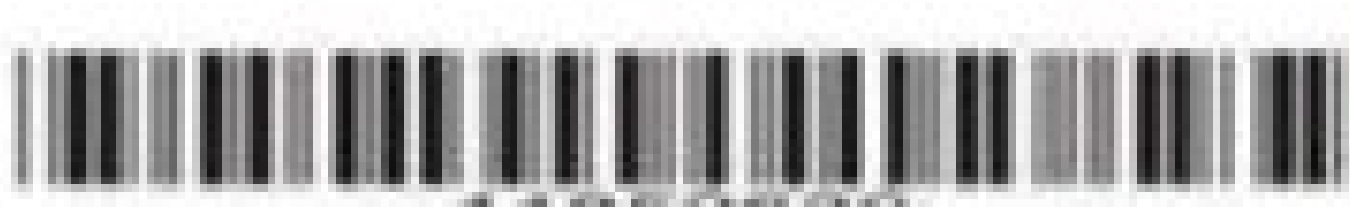
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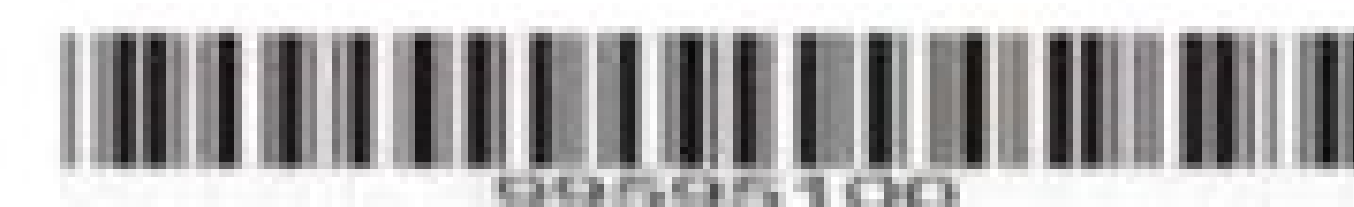
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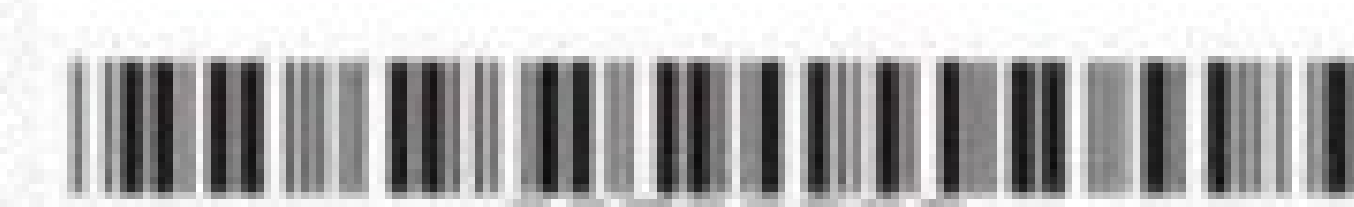
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that is so expensive, bulky and power-hungry. This is especially true when it comes to that one carry-always device: the phone. Projector phones have shown up in other countries, but in the U.S., mobile carriers dictate which devices make it to market. And these companies just aren't ready to take the plunge on the tech. That's not to say there aren't any devices on the market for the budding projectionist. A number of iPad docks and a few cameras—such as the 3M Shoot 'n Share CP40 and Nikon's Coolpix S1100pj—have projectors built in. These pocket-size devices can turn any gathering into a movie night or an instant slide show.

Flash Attack ➔ I'm worried about sites using Flash cookies to track my online activity. If I turn off Flash cookies in one Web browser, can they still track me in another? Do I need to turn them off individually in every browser I use?

While many people know that a quick trip to their browser's Preferences panel can allow them to disable somebody's ability to track online activity using regular old Web cookies, these new Flash cookies use Adobe's Flash plug-in to sneak in and do their dirty work. And in most cases, no browser setting can touch them. To turn these off, go to the Web page for the Adobe Flash Player Settings Manager (do a search for those words), click the tab for the Global Storage Settings panel and uncheck the box labeled "Allow third-party Flash content to store data on your computer."

But to your next question: Unlike regular Web cookies, which need to be turned off on every browser you use, changing the Flash cookies setting on one browser should carry over to other browsers on the same computer.

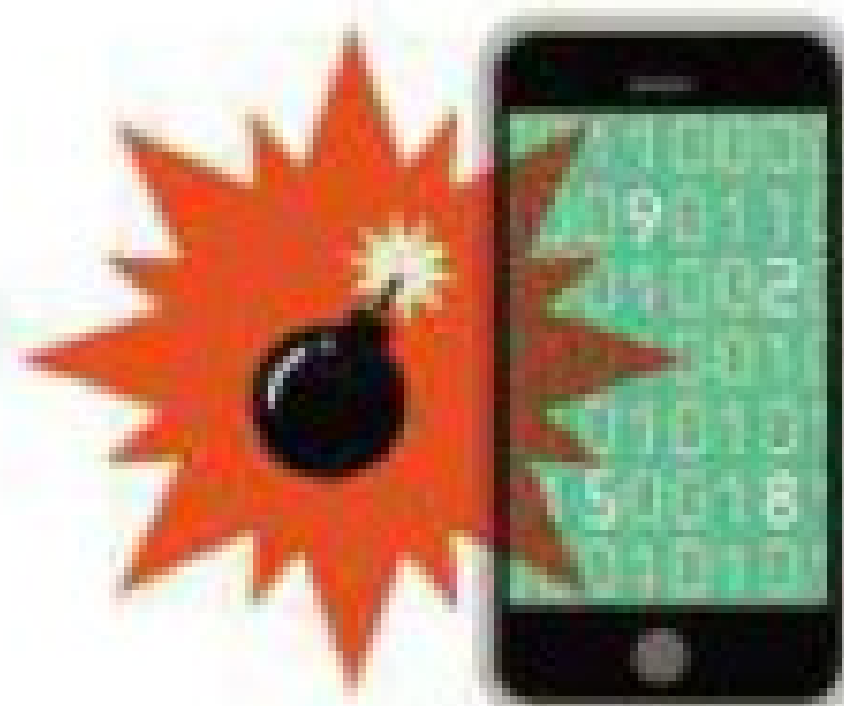
Scheduling Delivery

➔ Is there any way to schedule email delivery for a later time?

There are tons of reasons you might want the Send button to actually read Send Later—especially if you don't want

SOFT ERRORS WHY APPS CRASH

APP CRASHES. THEY FRUSTRATE IPHONE AND DROID USERS ALIKE. THEY CAUSE PEOPLE TO SIT AND STARE AT THEIR PHONES IN FRUSTRATION AND MUTTER, "WHY WON'T THIS WORK?" WE TALKED TO DAVID JANZEN, ASSOCIATE PROFESSOR OF COMPUTER SCIENCE AT CALIFORNIA POLYTECHNIC STATE UNIVERSITY, AND CALVIN CARTER OF BOTTLE ROCKET APPS TO FIND OUT WHY APPS CRASH. BY STEVE ROUSSEAU



Sloppy Code

➔ A majority of app crashes come simply from programmer error, according to Janzen, the most common occurring when a programmer references an object or variable that doesn't exist, technically called a null-pointer error. "When a programmer is developing an app, they have to be very careful to try and anticipate things that can go wrong," he says. "When they don't, that's what can cause a null-pointer." Another aspect is sloppy handling of multitasking, or threads, as programmers call them, Carter explains. Threads act like lanes on a highway: Most of the work is done in the right lane, or main thread, but the programmer can move work to other threads if it starts to get backed up.



Spotty Connection

➔ Even if programmers manage to keep their code tight and efficient, their handling of a poor network connection can force an app crash as well. An unreliable connection can cause your phone to retrieve bad data or even get no data at all, Carter says. "Many programmers, green and veteran alike, make mistakes with how to handle something going wrong when the data is en route," he says. "It's very easy to make an app that works great in your office on Wi-Fi but crashes for a user on 3G on a train." A solid app should plan for a drop in connectivity. "If you assume that you got [the data], then you get into trouble," Janzen explains.



Memory Management

➔ Although phones and tablets have advanced greatly in terms of CPU speed, developers still need to manage memory and processing power to keep their apps crash-free. It's very important for Android programmers not to tax the system when their app boots. If an app takes more than 5 seconds to launch, it's killed by the OS. "Having to worry about speed is a big concern," Janzen says. "You want to be real careful and just do little things to get it started." Unlike in the Android platform, iPhone developers must manually manage memory. They tell the OS which objects are in use and which aren't (also known as marking), and if they try to use an object that's marked as not in use, then—crash!

to seem *too* eager to respond to a message you just got. Thankfully, there are ways to write now and deliver later—even if you're not at your computer.

Gmail users can juice their account with Boomerang for Gmail, a free add-on that adds a Send Later button. Clicking it allows you to push the message through whenever you'd like (or at a random time, if you're in the mood). For now, Boomerang works only with the Google Chrome and Mozilla Firefox browsers, so definitely get one of those if you're using something else. If you've got Outlook 2003 or later, you can also schedule an email. Just click the Options menu at the top of the email's window and then select More Options and Delay Delivery.

Don't use Gmail or Outlook? You still have options: A number of online services, such as LetterMeLater.com, let anybody send an email at a scheduled time from their email account. **PM**

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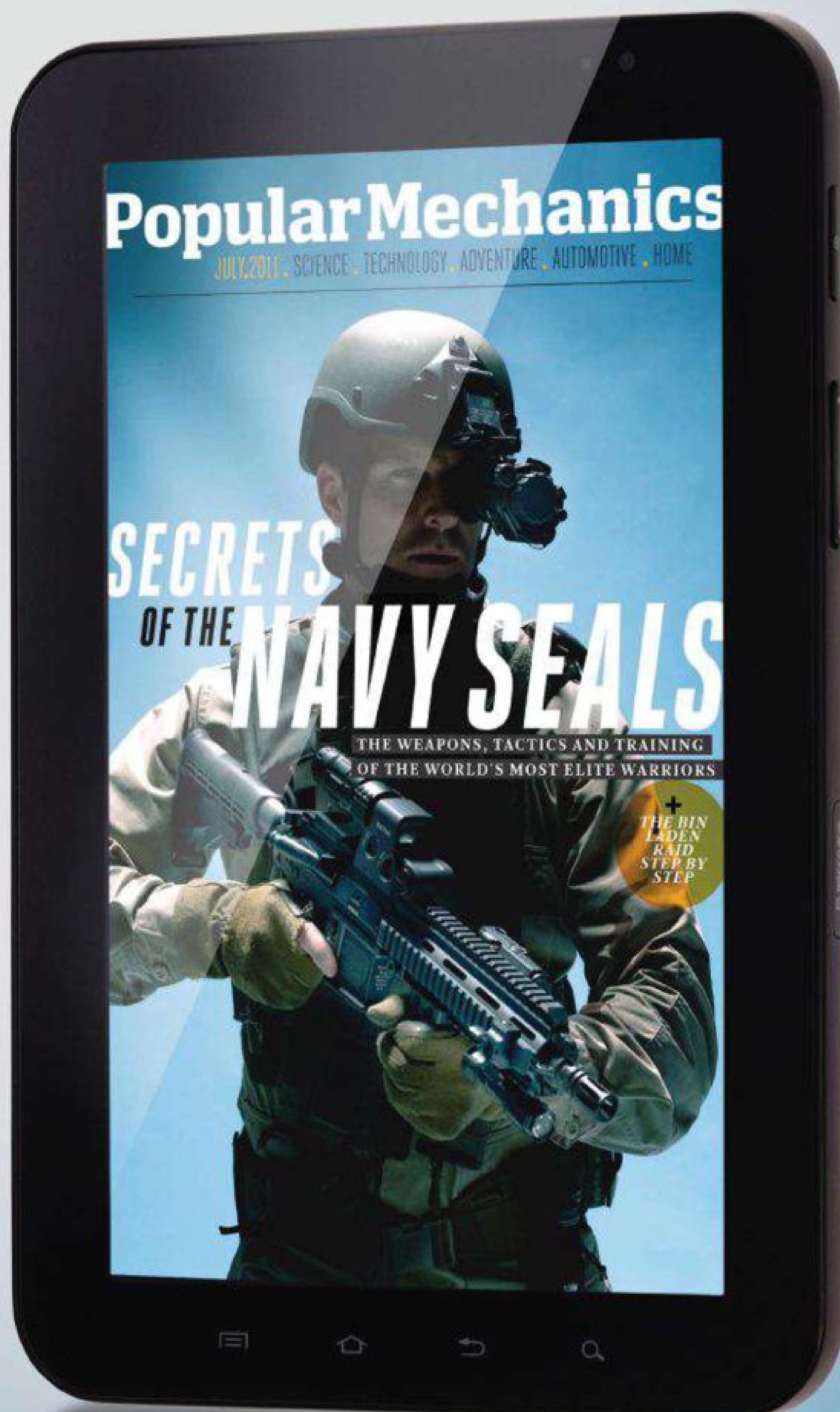
Since May, the Popular Mechanics team has taken every word and picture of its print issue, optimized it for the 7-inch Galaxy Tablet and added interactive functionality to enhance the individual stories. The result? PopMech: a must-download app! This month you'll enjoy the "Future of the Navy Seals" cover story, our annual "Hometown Hero Awards" feature, and the all-new "Total PM Garage."

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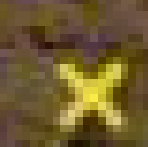
Trailing Basics

DON'T CONFUSE TOWING A TRAILER WITH DRIVING A CAR—THEY ONLY LOOK THE SAME. BY MIKE ALLEN

➡ **The trailer is doing a lazy samba** behind your SUV as you drive down the highway, swaying side to side far enough to intrude into the neighboring lanes and tug at your truck's rear end. It feels spooky and is, in fact, unsafe. Funny, the thing was as stable as an alpaca on a mountainside when you left this morning. Since then, the only changes you made were to fill the camper's water tank and to load the rear with camping gear and luggage.

Towing a trailer can be a trial. Seemingly minor details—like adding a couple of hundred pounds to the rear—can make profound changes in the rig's stability. But by following a few simple guidelines, you can stay on track, towing with the utmost ease and safety.

INSIDE



SHOP FIRE SAFETY + FREEING RUSTY BATTERY BOLTS + URBAN MYTHS

PHOTOGRAPH BY DANIEL HENNESSY

Release: StoreMags & FantaMag

DIY **Auto** TRAILER-TOWING BASICS

The Right Gear

➔ All hitches are not created equal.

The weight that your vehicle can tow is specified by the manufacturer and listed in the owner's manual. Find two numbers: the gross trailer weight (GTW) and the maximum tongue weight. With those figures in hand, you can then pick the appropriate hitch; they are split into five classes based on weight:

Class 1: 2000 pounds GTW/

200 pounds tongue weight

Class 2: 3500 pounds GTW/

350 pounds tongue weight

Class 3: 5000 pounds GTW/

500 pounds tongue weight

Class 4: 7500 pounds GTW/

750 pounds tongue weight

Class 5: 10,000 pounds GTW/

1000 pounds tongue weight

My advice is to install a hitch receiver that's heavy-duty enough to match your vehicle's GTW and tongue-weight spec, even if you're planning on towing only a small trailer. Don't forget to factor in the weight of the trailer's contents—including the capacity of the fresh-, gray- and black-water tanks—when you're shopping hitches.

Most hitches employ a removable drawbar, which holds the hitch ball. The bars come in two sizes: 1.25 inches (for lightweight pop-ups and bike racks) and 2 inches (for heavy loads).

Hitch balls come in three main flavors: 1⁷/₈ inches, 2 inches and 2⁵/₁₆ inches. Generally, the bigger the ball, the more weight it can support. If you own two or more trailers that call for different ball sizes, I recommend buying separate drawbars with the proper balls permanently attached.

Install the ball onto the drawbar to the proper torque—generally, several hundred foot-pounds. You'll have to use big tools and lots of muscle, and a generous squirt of threadlocker, which will keep moisture from penetrating the threads and freezing them up, allowing for easier removal.

Setting the Hitch Height

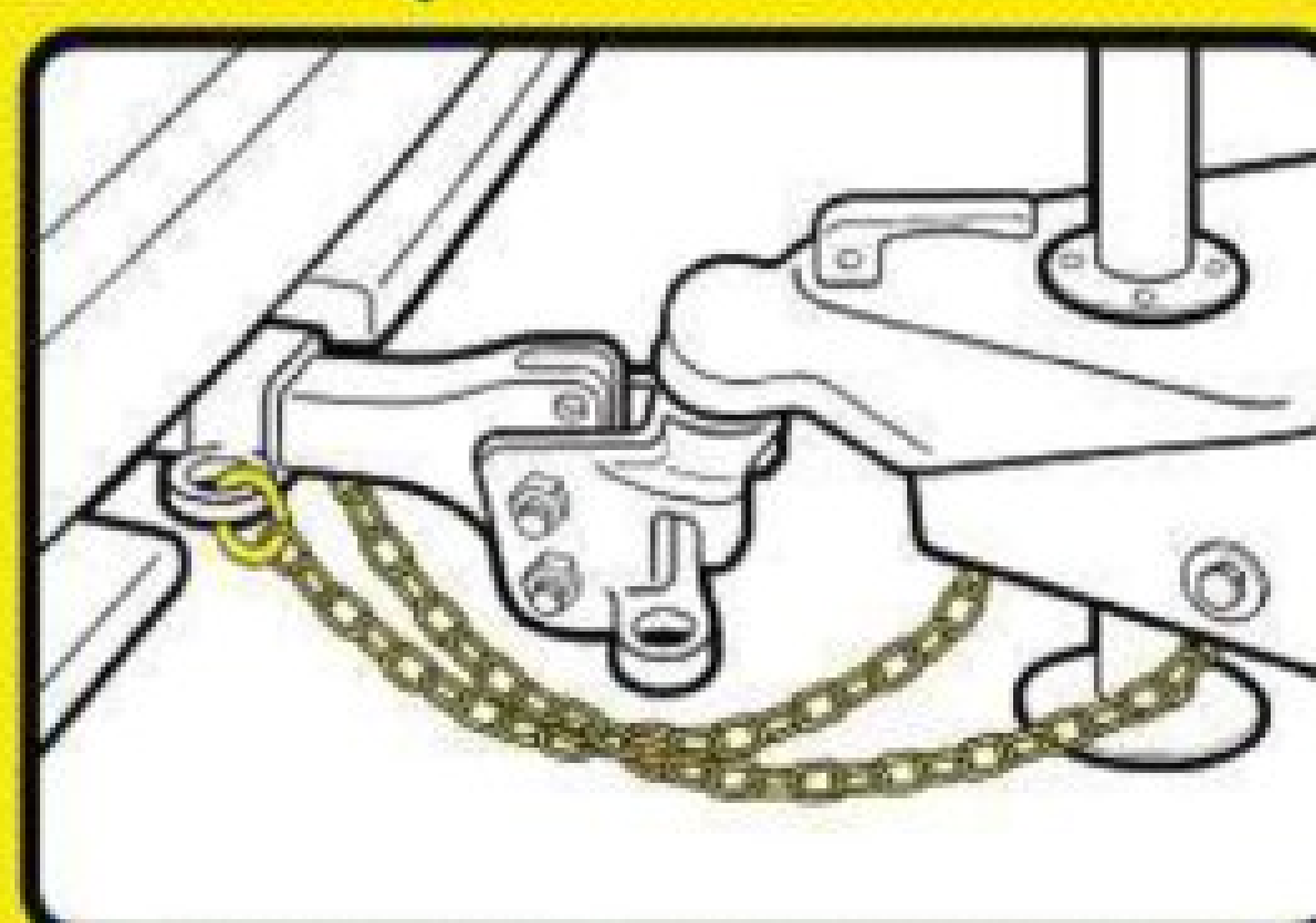
➔ **It's important** that the loaded trailer be level to the ground when it's attached

to the vehicle, and that you trim the trailer's flatness either with an adjustable drawbar or by finding one with the right offset. (If you end up using an offset drawbar, make sure it's rated to handle the trailer weight.)

First, you need to find the height of the trailer's tongue when the trailer is level. Set up the trailer on flat pavement. Run the tongue jack up and down or prop it up on some scrap lumber until it's level. You can determine this by placing a carpenter's level on the tongue or by eyeballing the trailer from the side from a distance of about 50 feet. Measure from the ground to the top of the ball socket. Park the vehicle you'll use to tow the trailer on level ground too. Then measure from the ground to the top of the hitch receiver and add 3 inches to accommodate the height of the ball.

Typically, the ball is a good bit higher than the trailer tongue, so the difference is the approximate amount the drawbar will have to be lowered. I say approximate because the weight of the trailer will compress the vehicle's springs. Hook up everything (with

ONE ➔ Cross the Chains for Safety

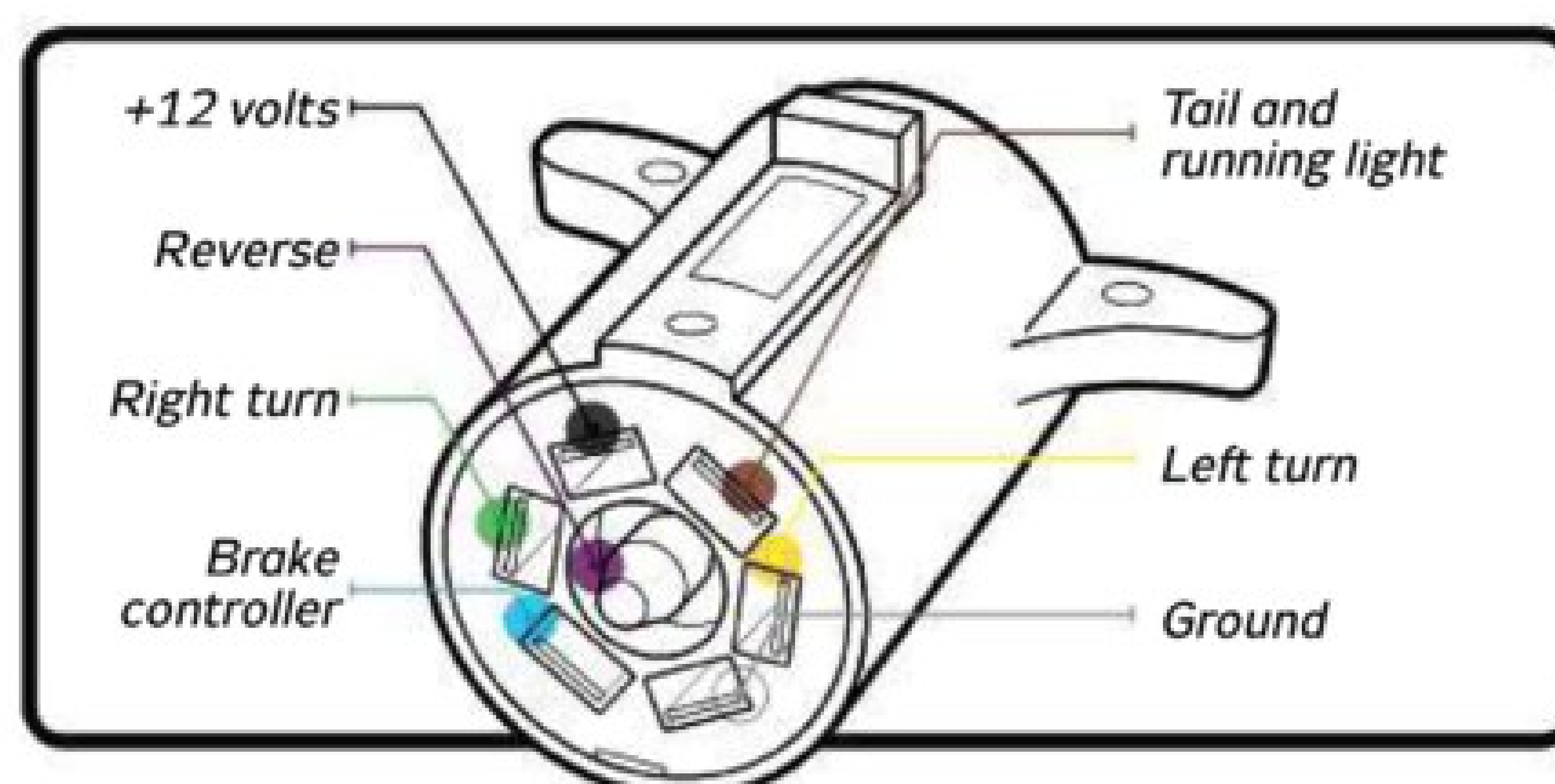


Chains serve as the hitch of last resort: If the tongue ever loses its grip on the ball, the chains will keep the trailer from vaulting the guardrail into oncoming traffic or something equally inconvenient. Cross

the chains under the tongue—if it slips free, it'll land on top of the crossed chains rather than hitting the pavement. A bonus of the X configuration: The chains won't come up short in tight turns.

TWO ➔ Check the Trailer-Wiring Harness

This industry-standard plug and socket wiring and color-coding scheme should make it easy to install the connector properly to the tow vehicle's harness. Spray the contacts with dielectric grease to prevent corrosion.



THREE ➔ Always Check the Brake Battery



Trailers with electric brakes rely on a small gel-cell battery to initiate stopping when the breakaway lanyard is pulled. Normally, the battery charges whenever the truck engine is running. But it's smart to check it before

hitting the road; faulty wiring or lengthy storage can sap the juice. Use a test light or voltmeter to make sure the battery is alive; if not, hook it up to an external charger to ensure the brakes are in working order.



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DIY Auto TRAILER-TOWING BASICS

FOUR → Set Your Tongue Weight

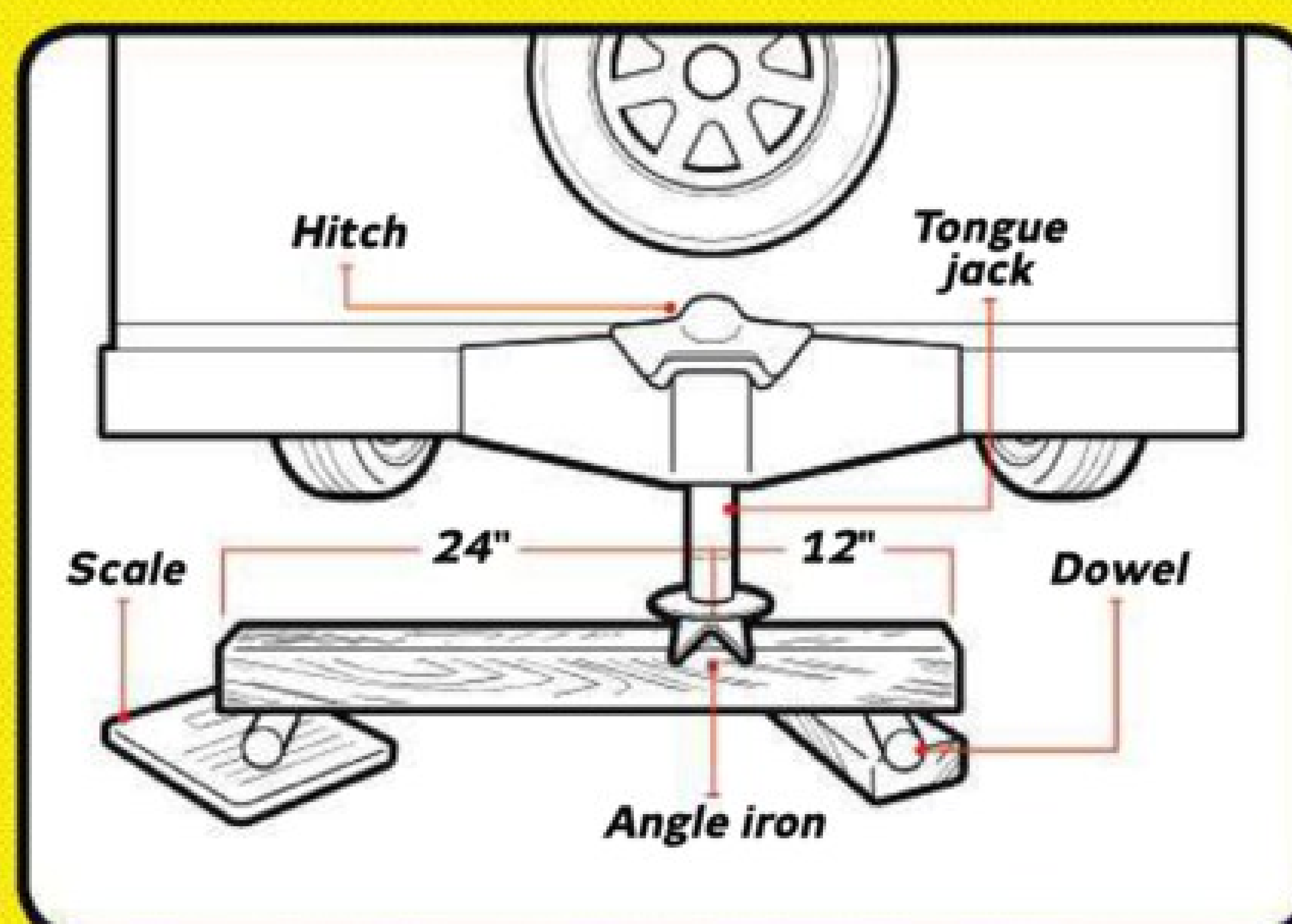
Swaying trailers are almost always the result of insufficient tongue weight, because adding tongue weight adds stability.

If there is zero tongue weight, the trailer's center of gravity (CG), the point around which

it pitches, yaws and rolls, is centered between the tires' contact patches. This will provide no stability, specifically in yaw, or sway. Adding tongue weight, by moving cargo in the trailer forward, pulls the CG

forward of the tire contact patches. The drag of the tires will tend to pull the CG back onto the centerline of the truck and trailer. The more tongue weight, the farther forward the CG goes, and the more stability in sway,

right up until you add too much tongue weight for the tow vehicle's rear suspension to handle. Industry-wide, the target recommendation for tongue weight is 10 to 12 percent of total trailer weight. Here's how to check tongue weight if your trailer weighs so much that your bathroom scale won't read high enough. With the tongue resting on the beam one-third of the distance between the pivot and the scale, a 140-pound reading means that the total tongue weight is 420 pounds, just about right for a 4000-pound trailer.



the trailer loaded) and again measure the trailer's attitude. You'll likely have to adjust the drawbar height again. I keep a few different drawbars on hand, but an adjustable one is a good investment.

Loading Up

➔ **Sure, you know** how much the trailer weighs, because it's printed right there on the registration, right? Don't believe it, as the listed weight probably doesn't include a camper's furniture or the cargo on a utility trailer. Accessories added at the dealership, like an auxiliary battery, ramps, tie-down rails and whatnot, can make the gross weight climb substantially. (Don't complain to the trailer manufacturer—if your state charges by weight for the registration, you're saving a couple of bucks.) The only real way to know is to weigh it, which you can do for a minimal fee at most stone-and-gravel yards, feed stores and truck stops.

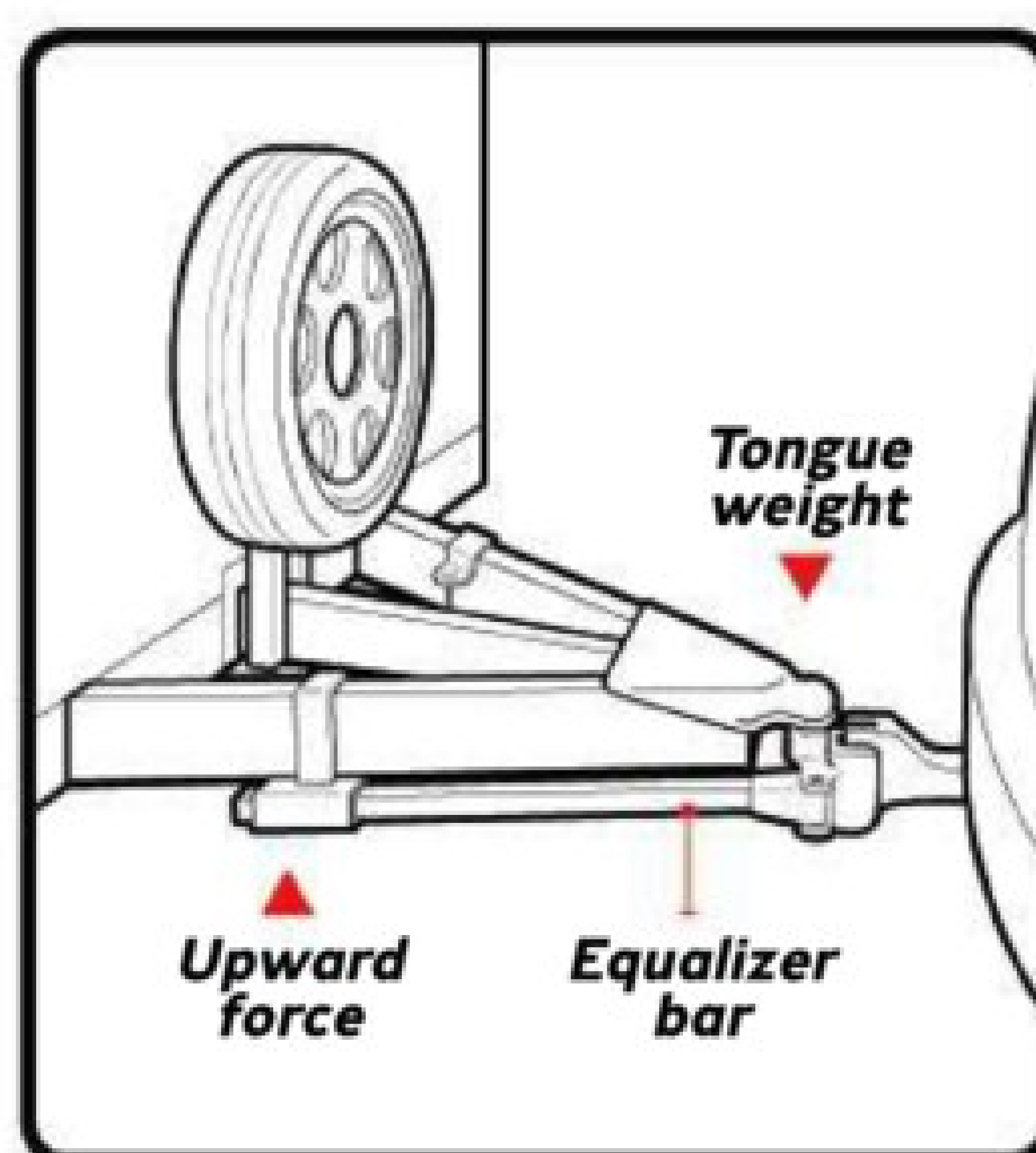
Before you head to the scales, load up all the items that you plan to haul, and fill the water and propane tanks. After you arrive, first get the overall trailer weight by disconnecting the trailer and resting the entire rig, wheels and tongue jack on the scale. Next, find the tongue weight by hitching up the trailer and leaving only its tires on the scale. The difference between the two measurements is the tongue weight. You want roughly 10 percent of the trailer's weight on the tongue. Shift the cargo fore and aft until you get the correct weight distribution. Note the position of the load (a camera phone comes in handy for this) so you know for next time. And if you're changing cargo but don't have time to visit the scales, use our home-brew method (see "Set Your Tongue Weight," above) to get an accurate measurement.

Don't trust anything to stay put in or on a trailer once you're under way. Clip or bungee cabinet doors and drawers. Use ratchet tie downs to keep stuff in place.

FIVE → Set Up an Equalizing Hitch

Once you've dialed in enough tongue weight for stability (about 10 percent of the trailer's weight), there may be too much pressure on the vehicle's hitch. Equalizing bars (right) induce a rotational force around the hitch and pivot horizontally, transferring some of the tongue

weight to the vehicle's front axle. The stiffness of the bars needs to be correct for your particular trailer, so consult the manual or a trailering specialist. I generally adjust them so that when the equalizer bars are installed, the trailer hitch rises back to within 1 inch of its unladen ride height.



Tires

→ **Inflate the tires** to the trailer manufacturer's maximum recommended cold pressure. Heat is the tires' enemy, and a properly inflated tire will run cooler. Be even more careful of the small tires on light-duty trailers—the tiny outside diameter means they spin faster. A high-speed run on a hot day with a ton of bricks on board could overheat the tires or wheel bearings.

Hooking Up

→ **Whenever you hook up** the trailer, check that all of the lights are working. You can do this without making four trips up to the cab and toggling on all the turn signals and brake lights in succession. Turn on the parking lamps and the hazard flashers. Walk to the back of the trailer. If the parking lamps and flashers are on, you've got turn signals and brake lights, because they're the same filaments as the hazards. This assumes, of course, that the truck's brake lights are working.

On the Road

→ **Regardless of how** tightly you cranked the tie downs on that car, bike or ATV, road vibration can loosen them. So, about 10 to 20 miles after you depart, stop and check their tension. After a few hours on the road—and every time you stop—inspect the trailer. Make sure the hitch and wiring are secure. Kick the tires to see if they're properly inflated. Tire pressure and properly functioning wheel bearings are crucial. Heat is the telltale sign: You just don't want any tire or wheel bearing to be significantly warmer than the others. I use an infrared thermometer—or my calibrated palm—to check the temperature of both. A tire becomes hotter if it has less air pressure than the others, so check for a leak. A toasty wheel bearing is on the verge of failing. At the very least, pop off the bearing cap to see if there's sufficient grease in the bearing cavity.

Every morning, check the tow vehicle and trailer tire pressure, as well as the trailer lights and brakes. Ditto for any tie downs. Don't forget to shut off the propane at the tank and the electric water pump at the breaker. If you've got an auxiliary battery, be sure it's turned off and connected to the vehicle charging circuit so it'll charge while you're under way.

One last tip: If you're trailering to a campground, leave the freshwater tank empty until you're on-site. No sense in towing several hundred pounds of water cross-country. Ditto for breaking camp: Empty the black-, gray- and fresh-water tanks at the campground instead of towing all that extra weight around.

PM

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Car Clinic

by Mike Allen

Q+A

Q Foil That Fire

I happened to notice a disturbing thing in a couple of past photos of the

PM shop. It's a drum of some sort of solvent along the back wall with oily red rags on top of it. Don't you know anything about shop safety? Those rags should be in a proper container. Also, I understand that you do welding and plasma cutting in the same space. Sounds like a good way to start a fire.

A I'll give you the fire danger from flying sparks hitting the solvent container. My bad. That particular drum of lacquer thinner has since been used up and removed. Now I keep smaller containers of thinner up on a shelf on the other side of the shop alongside the paint and cleaning solvents, far from any ignition source.

But I'm not too worried about the oily rags, which are generally thought of, correctly, as a fire hazard. The oil on those particular rags is motor oil and maybe some wheel-bearing grease. Any oil that stays oily after exposure to air is pretty low on the list of things that can initiate spontaneous combustion. Other things that have been demonstrated to spontaneously burst into flames are compost heaps, coal bunkers and large containers full of fine metal shavings.

Here's what can happen: Paint, linseed oil, tung oil and some solvents—

those that polymerize when exposed to oxygen—generate heat while drying. (Polymerization is what makes epoxy set and paint dry. Shorter molecules combine into longer chains, getting less fluid as the chains get longer. Eventually, they become solid as the links become permanent.) It's referred to as an exothermic, or heat-releasing, reaction. A pile of rags, say, ones used to rub in a linseed-oil-based stain, will heat up as the linseed oil oxidizes. If the pile is in a warm, protected place, and stacked deep enough, the reaction will accelerate as the rags get warmer. And over a couple of hours, the process is easily capable of generating enough heat to ignite the rags and start a fire. Then it's goodbye, shop.

Motor oil and grease don't polymerize much, if at all. They remain liquid and don't combine rapidly with atmospheric oxygen. So a pile of oily shop rags really



Keeping oil-soaked rags in an airtight container will prevent them from getting enough oxygen to catch fire spontaneously.

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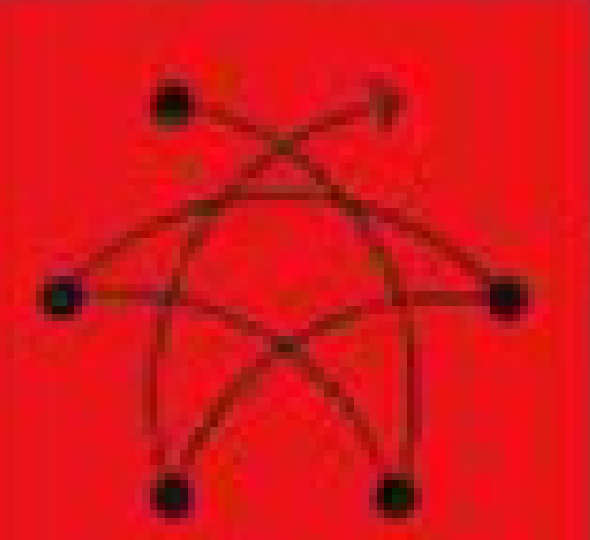
isn't at risk for spontaneous combustion. The PM shop is mostly used for automotive and metal fabrication work, so we rarely use solvents or wood finishes that pose a spontaneous-combustion threat.

Nonetheless, I went out and bought a proper airtight and fireproof oily-rag storage can. Not only does its lid close tightly enough to restrict the oxygen that feeds spontaneous combustion, it will contain any smoldering fire that manages to rear its head. Besides, it'll keep the shop better organized. Thanks for pointing this out.

Tenacious ➡ Do you have a brilliant idea how to loosen a frozen/rusted battery bolt? I've tried Vise-Grips, WD-40, wrenches . . .

The first thing I always do whenever there's any reason to remove battery clamps is to slowly pour a pitcher of lukewarm water over them. Lead and copper salts from the battery posts and the brass terminals are highly soluble. Half the time this warm bath is all that's needed to loosen the clamps, though applying a little penetrating oil before you pick up your wrench might also help. Don't be surprised if the nut or bolt has corroded significantly from its original size. Avoid the use of vise-grip pliers until you're desperate: The brass nuts are very soft and will distort and get even harder to remove if you squeeze them. A box wrench is better than an open-end wrench, and a six-point socket is better than a 12-point. The best tool to use would be a flare-nut wrench, which grips all six points of the nut or bolt head.

Caution is necessary. The battery post is dead-soft lead and not too difficult to shear off completely if you ham-fist the clamp. I've been forced to resort to using a



READER FEEDBACK

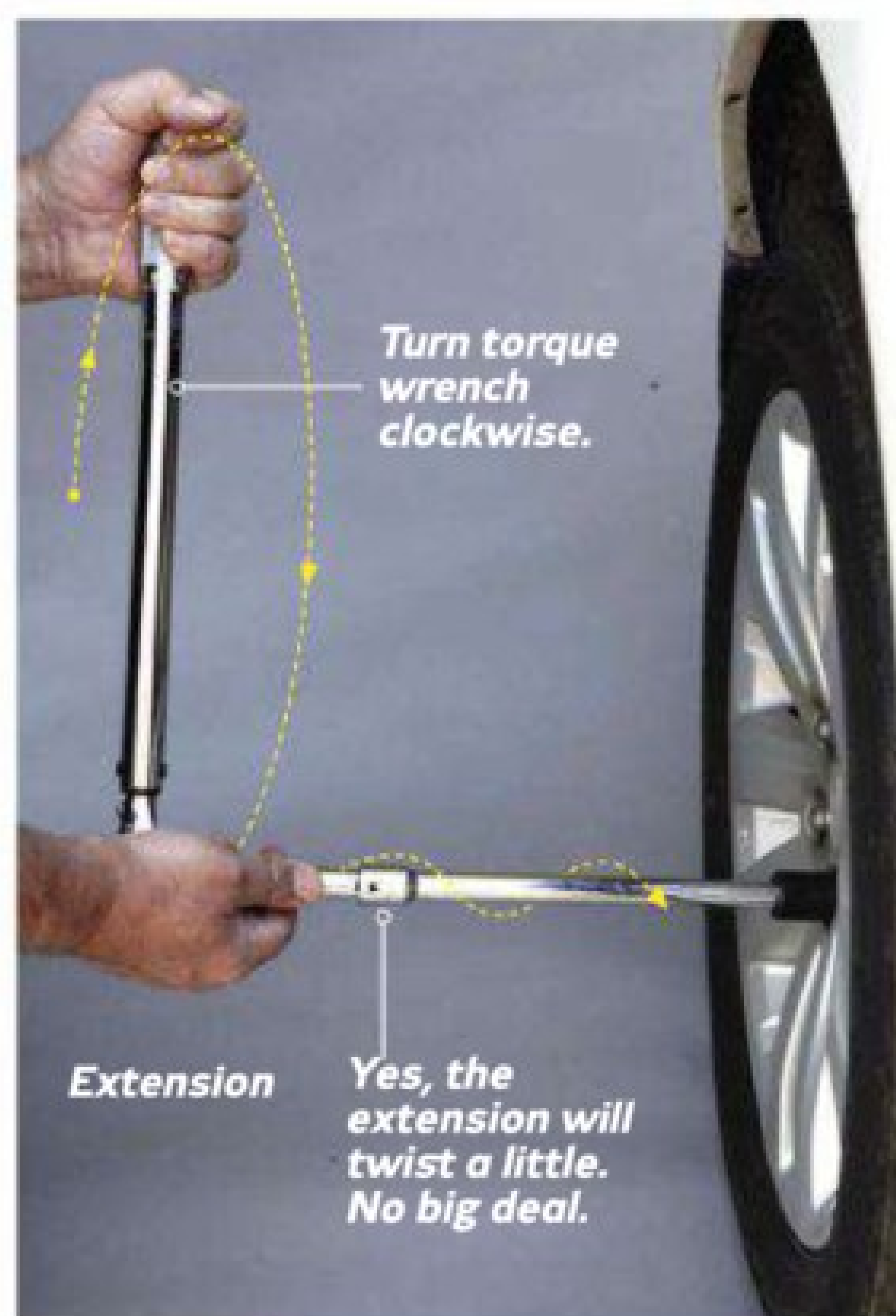
TWISTED



IN SPITE OF WHAT THIS READER MAINTAINS, YOU CAN USE AN EXTENSION 6 FEET LONG TO TORQUE LUG NUTS OR ANY OTHER CRITICAL FASTENER. JUST GO SLOWLY.



PM READER: You stated in your Saturday Mechanic "Torque Wrench Basics" (April 2011, page 105) that an extension between the socket and torque wrench will not affect the torque applied to a bolt or nut. All I can say is I'm glad you're not building my engines. Although the torque wrench will certainly click at the appropriate setting, that



extension will absorb force and the actual applied torque will be lower than your setting.



MIKE ALLEN: A standard straight extension, mounted between the centerline of the torque wrench's drive and the socket, will have no effect on the torque applied to the fastener. Don't be confused by an extension that positions the socket away from the

torque wrench's head. I stand by my original assertion; you are incorrect.



PM READER: I'm afraid I'm not. Consider the fact that they create torque-limiting extensions and sockets for tire shops. Any extension will absorb torque, and the longer the extension, the more torque will be translated into the distortion of the extension. It's basic physics!



MIKE ALLEN: Yes, "torque sticks" will reduce the torque applied to a fastener by an impact wrench. They do so by winding up like a spring, absorbing some of the peak torque generated by the wrench's internal hammers.

Impact wrenches use an air-powered motor to spin weights, hammers, inside a free-spinning housing. The hammers hit the housing, which in turn spins the

output-shaft drive square. The hammer will turn the shaft only a few degrees for every whack. A torque stick will wind up like a spring and rebound enough between impacts to limit the max torque.

However, in a steady-state application, like the relatively smooth and slow increase of torque applied by hand-tightening a torque wrench, an extension will have *no effect*. Yes, an extremely long extension might twist along its length enough to require a few extra degrees of rotation on the torque wrench to rotate the fastener before the wrench mechanism clicks. But when the wrench ultimately clicks, the torque applied to the nut or bolt will be the same, *regardless of how long the extension is*.

Torque sticks are far too inconsistent for me, dependent as they are on the shop air pressure, how long the hose is, how long it's been since the mechanic oiled his tool and how long he holds the trigger. I always use a torque wrench.

cutoff wheel on a Dremel tool to sever a bolt without damaging the post. Don't forget to use brass—preferably lead-plated—hardware to put it back together. Zinc- or cad-plated steel will rapidly corrode to the point of failure. You can get the appropriate lead-plated bolts and nuts at the auto parts store.

This Old Nugget Again? In late 1989 or early 1990, you ran an article about someone in the Midwest who "redrilled" the intake manifold so that any 327 or 350 engine would get 68 miles to the gallon (my father-in-law's friend bought an accidental-release "experiment car" with this on it in the '90s). Also in that issue was a professor from Washington state who redesigned a car to run off water and averaged 55 mpg across the U.S. on 1 gallon of water! GM bought up the patents and quashed them.

My point is, if the technology was there, why don't you reprint these articles? If we do not use these patents we will be even further behind in the world. You can pressure carmakers to build these vehicles and make us less dependent on foreign oil. Sigh. I've been working here at this same desk since the mid-'80s. POPULAR MECHANICS never published any such article. You've taken the bait on yet another urban legend. No simple intake manifold modification can improve fuel economy several hundred percent, as the legend asserts.

And you can't make a car run on water, as I've written about and appeared on national television repeatedly to report. Check the archives on popularmechanics.com to see what I've written.

"My father-in-law's friend," indeed. This particular urban legend—someone accidentally buys a research vehicle with incredible mileage—has been around for generations. GM (or Ford or Chrysler, I've heard the same story applied to all of the Big Three) did not buy up the patents and bury them. Car-makers globally are desperate to increase fuel economy. Anyone who had

any such technology would have an immediate, unbeatable market advantage. The engineers who design cars constantly look for tiny percentage increases in efficiency to stay competitive. The thought that a car manufacturer would deliberately quash this technology is just ridiculous.

For the straight skinny on these myths and many, many more, try snopes.com. **PM**

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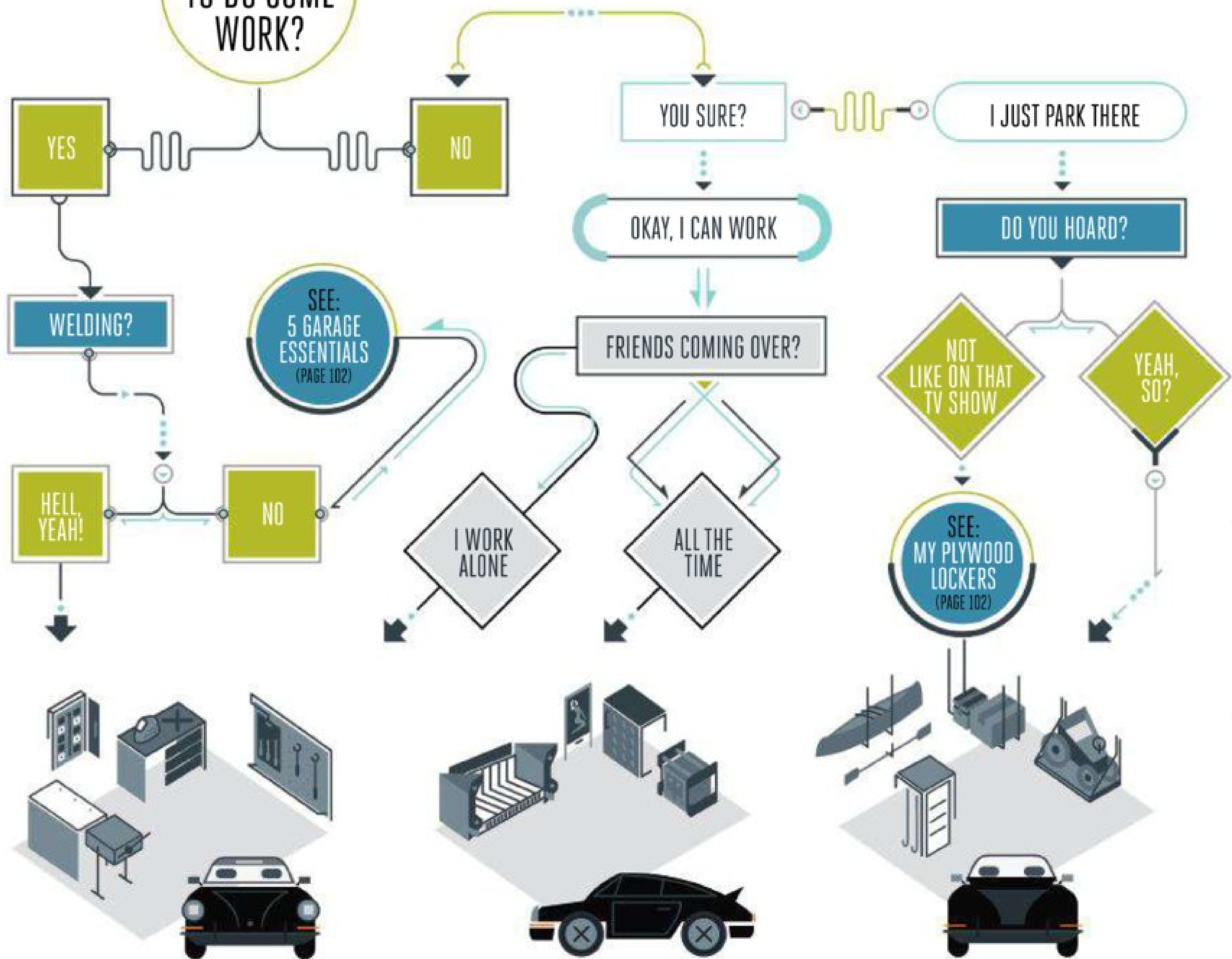
DIY

Home

The Ultimate Garage

IT HAS A CONCRETE FLOOR, A DRAFTY DOOR AND HUMMING FLUORESCENT TUBES. IT SMELLS OF DETERGENT, GREASE AND THE EARTHY TANG OF CUT GRASS. IT'S ALL YOURS. SO WHAT DO YOU WANT TO DO IN THERE? *BY HARRY SAWYERS*

WANT
TO DO SOME
WORK?



WORKSHOP

MIG welders require a dedicated 30-amp circuit breaker. Unless you're wired for serious metalworking, you'll need to add a subpanel. For small jobs, even a basic shop needs a bench, task lighting and a pegboard (*page 100*).

HANGOUT

A great garage rec room never requires a trip indoors. Calendars, old license plates, pinups and other aesthetic flourishes aside, you'll need a beer fridge, a dartboard, comfortable seating and some tunes (*page 101*).

STORAGE

By stacking storage up high, you can fit a lot in a garage and still have room to park a car. Go with overhead bins, a wall-mounted lift, salvaged cabinets and capacious open shelves or plywood lockers (*page 102*).

INSIDE



PROJECT PLANS + ESSENTIAL TOOLS + SWEET GEAR



THE COMPETENT MAN'S LABORATORY

Jack Olsen's shop in Los Angeles began as an ordinary two-car garage full of boxes and junk. Despite his novice status as a welder, tile setter and carpenter, Olsen saw the space's potential. "This is stuff you wouldn't try in your living room or kitchen, because if you did it at a B-plus level, you wouldn't be able to live with it," he says. "In a garage, you can test your wings. The garage is a safe place to screw up." — AMANDA DEMATTO

1 Cabinetry

At first, Olsen wanted the ease and access of open shelves. But when they got full of sawdust and random tools, he realized he had to build cabinets. "I kept trying carpentry until I wasn't awful at it," he says. Olsen also got a deal on Strong Hold cabinets, which, he says, are "rated at 1900 pounds per shelf." A new set costs a few thousand dollars, but Olsen spent less than \$1000 in total for a used set. "I keep an eye on eBay and Craigslist," he says.

2 Pegboard

Olsen organizes tools by job. Carpentry, welding and metal fabrication have specific work areas. He uses standard pegboard and custom racks such as the one he designed to hang his clamps (above). Olsen laid it out by arranging his clamps on the floor like a puzzle and outlining each one's position in chalk. OCD? Maybe. "But if you don't spend half your time looking for a misplaced tool, you're more efficient," he says.

3 Workbenches

After determining 37 inches to be his ideal working height, Olsen built eight benches at the same level so he could bridge long stock across the room. The metalworking bench has an inch-thick steel top; welding occupies its own fireproof zone; a woodworking bench has butcher block; and fold-down benches throughout save space and conceal tools. "Some tops are plywood; some are thinner steel," he says. "I used whatever I was able to get secondhand."

4 Lighting

Cake pans from a restaurant supply store became light fixtures with Olsen's alteration: "I thought, light fixtures are expensive. If you just turn over this cake pan, it makes a good lamp." He drilled a hole in the bottom, installed a socket and bulb kit, and then ran wiring to the fixture. A reflective concave surface provides bright task lighting on the benches. Olsen welded cantilevered arms from the walls to hold the lamps. "They're serviceable," he says.

PHOTOGRAPHS BY JACK OLSEN

THE ALLURE OF THE GARAGE

Bedroom, bathroom, kitchen, dining room, den: In the pantheon of household floor plans, they are mere distractions—pretenders to the throne. It is the seemingly humble garage, after all, that reigns supreme in our dreams of a better, faster, more capable manifest destiny. Let's just man up and admit that we live in a domesticated residential world in which mothers, girlfriends and wives ultimately decide what goes where. They determine the relative importance of, say, a new living-room credenza over a seasoned foosball table. Their dominion, however, falls short of the garage—the last resolutely unclaimed piece of household real estate. Inhospitably raw, unapologetically uninsulated and categorically as much outside as in, the garage is our final frontier, where anything seems possible. Man cave, workshop, laboratory, gym, arcade, bar, rehearsal space, startup incubator—it is an empty vessel easily converted to private retreat, adult playground and/or rugged workspace. The possibilities are endless, and the creation stories—HP, Apple, countless metal and jam bands alike—legendary. There are no limits to what a man can achieve inside his garage and, equally important, no prying eyes to cast judgment. What happens in the garage stays in the garage—until it's ready to race, rock or start a revolution. How many powder rooms can truly hope to match that? — ROBERT MORITZ



GARAGE GEAR

Beer Fridge Deluxe

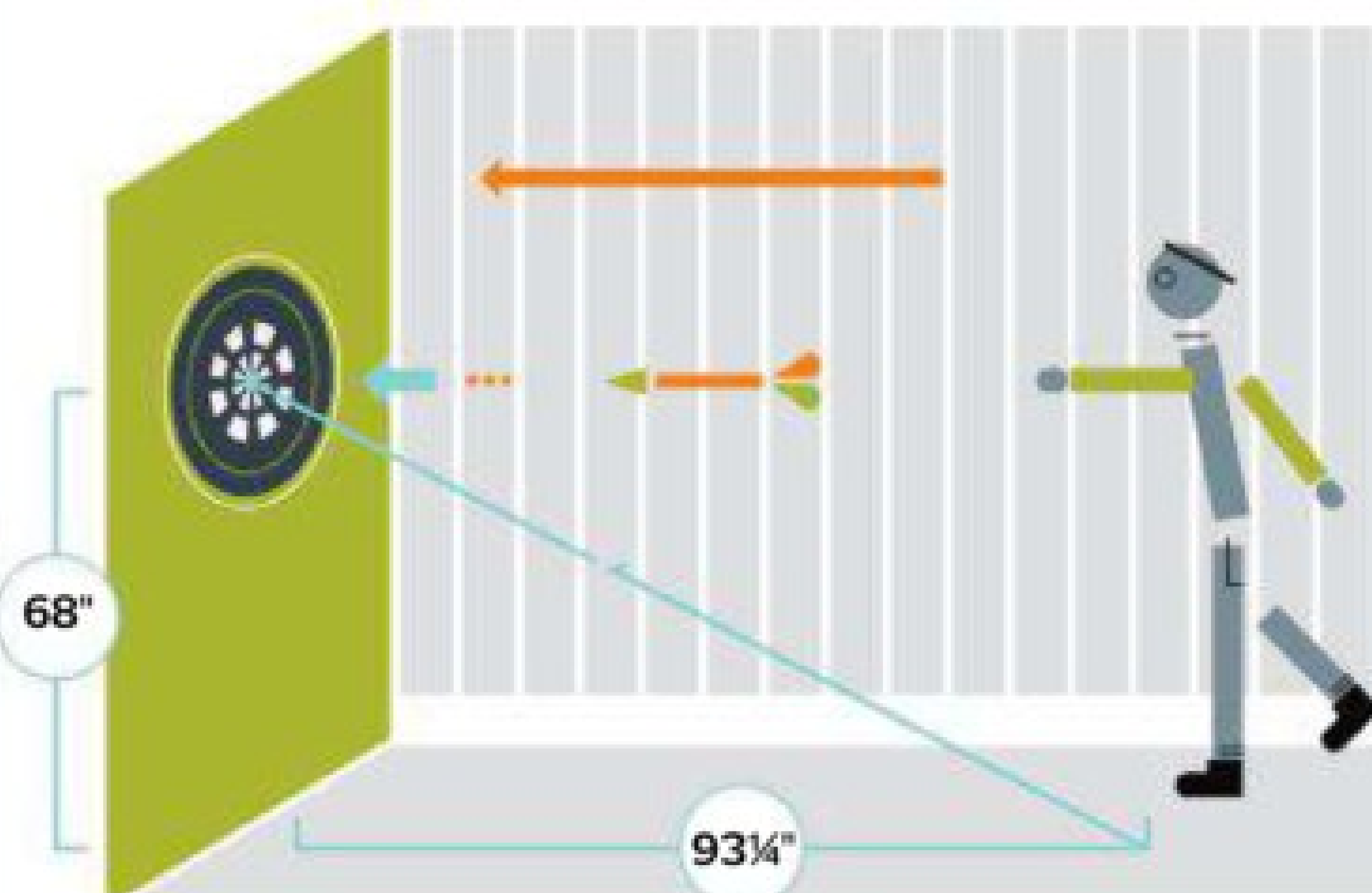
All due respect to the cooler, but it's not a long-term beer plan. Bronx, N.Y.-based Summit Appliances adds a tough diamond-plate finish to the 120-can model FF7BDPL, a machine that, half-full, gets a warm beer frosty in 2 hours (\$585).

Bulletproof Boombox

Any old speakers suffice for a bare-bones garage jam. But the Bosch Power Box 360D can charge batteries, power corded tools, dock an iPod, repel sawdust, fall off a truck bed and take a direct hit from a sack of Quikrete (\$199).

Cadillac Couch

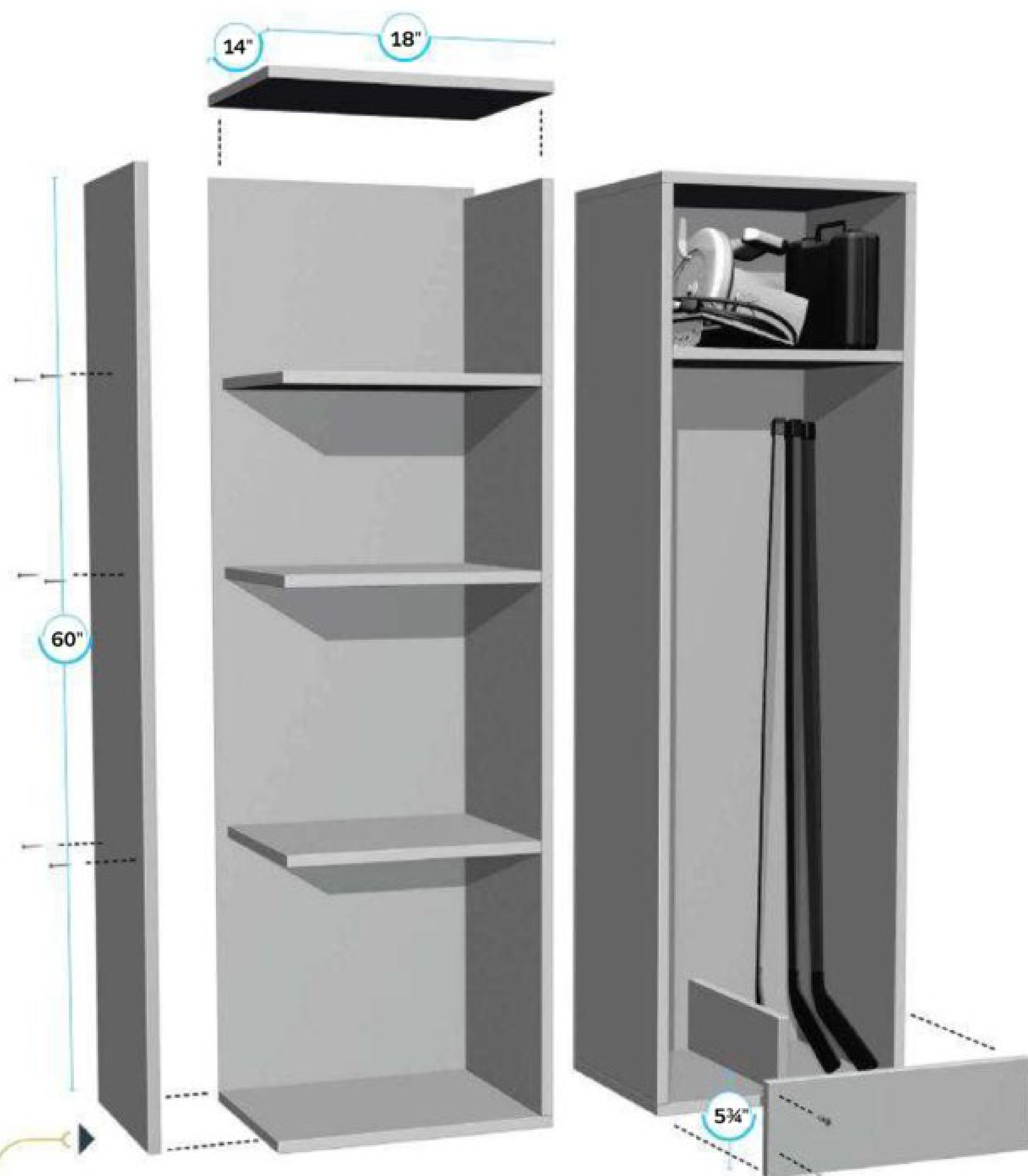
Leaning up against the bumper just isn't as relaxing as sinking right into it. Josh Kreuder of sweetsofas.com builds couches and chairs into restored body sections of genuine classic cars—no reproductions. Relax. He uses junkers (\$7950).



HOW TO HANG A DARTBOARD ... Low-impact sports release the garage hangout's surplus competitive energy. Set up a proper duel according to American Darters Association rules: Hang an 18-inch-diameter bristle-type board with the center of the bull's-eye 68 inches from the floor, and mark the foul line at 93 1/4 inches from the board. Cross it and you forfeit the throw. Sharp steel projectiles are in play, so consider adopting Article 10 of the Long Island Dart Association's rule book: No heckling. — H. S.

DIY

Home ULTIMATE GARAGE: STORAGE



MY PLYWOOD LOCKERS

Once I figured out how to build a storage locker out of a single sheet of $\frac{3}{4}$ -inch plywood, it wasn't long before my custom power-tool closet was overwhelmed by the kids' sports gear. Good thing making another was so easy. — BRETT MARTIN

RIP WOOD

The single panel creates a 60-inch-tall, 18-inch-wide and 14-inch-deep box with a back. Panel scraps become shelves

and dividers. Using a circular saw, rip the sides and back to width. Cover the parts in water-based satin polyurethane to get a durable finish. Give it 4 hours

to dry, then cut the pieces to length. Save time by skipping the sanding—rough cuts work fine here.

BUILD A BOX

For simplicity, the box is built with butt joints. Assemble the top, sides and bottom by gluing the edges, drilling $\frac{1}{8}$ -inch pilot holes and driving three 3-inch drywall screws per joint. Glue and attach the back panel, driving screws through the back, into the sides. To plan shelves, measure down from the locker top, mark a level line with a square, drill pilot holes and fasten

screws through the locker sides and into the shelves' ends. Add a $5\frac{3}{4}$ -inch face along the bottom to conceal a 5-inch-tall divider—it keeps rakes and brooms untangled.

MOUNT UP

Lifting the locker a foot off the floor gives room beneath to sweep or to store more stuff. Either use cleats to hang the locker or mount the cabinet directly by driving screws through its back and into the garage wall studs. Load up the locker, but don't delay—before long, it'll fill up with baseball bats and hockey sticks.

5 Garage Essentials



Vise → Any serious grinding, tapping or filing begins with a firm grip in this bench-top clamp. Bolt on a Craftsman Wilton-style or an American-made antique. For a portable vise, get Rockwell's Jawhorse.

Flooring → Modular tiles upgrade concrete's look, comfort and ease of cleaning. Try RaceDeck's interactive floor designer (racedeck.com). If tile is too much, at least lay an antifatigue mat by the workbench. Your feet will thank you.

Hooks → Vinyl-coated bike hooks make open framing an asset. Mounted to joists, J-hooks hold string trimmers and circular saws, L-hooks hang ladders and U-hooks coil hoses and ropes. For wall systems, try Slatwall or Gladiator's GearTrack.

Power → A 4-foot, 10-outlet power strip fastened under a workbench hooks up corded tools and battery chargers. Use a ceiling-mounted reel to corral a 100-foot extension cord rated for outdoor use.

Safety → Impact-rated glasses, a face shield, a respirator, goggles rated for chemical splash protection, leather gloves, disposable nitrile gloves, earplugs and a first-aid kit. Hey, accidents happen. — STUART DEUTSCH

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Home ownership is under attack. There are those who would take away programs that help people become home owners, remove tax benefits like the mortgage interest deduction, and make it more expensive to attain and maintain home ownership. The decision to own a home is a very personal one, but we believe that anyone who is able and willing to assume the responsibilities of owning a home should have the opportunity to pursue that dream.

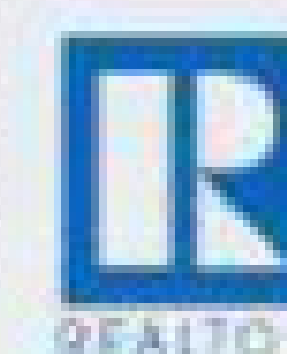


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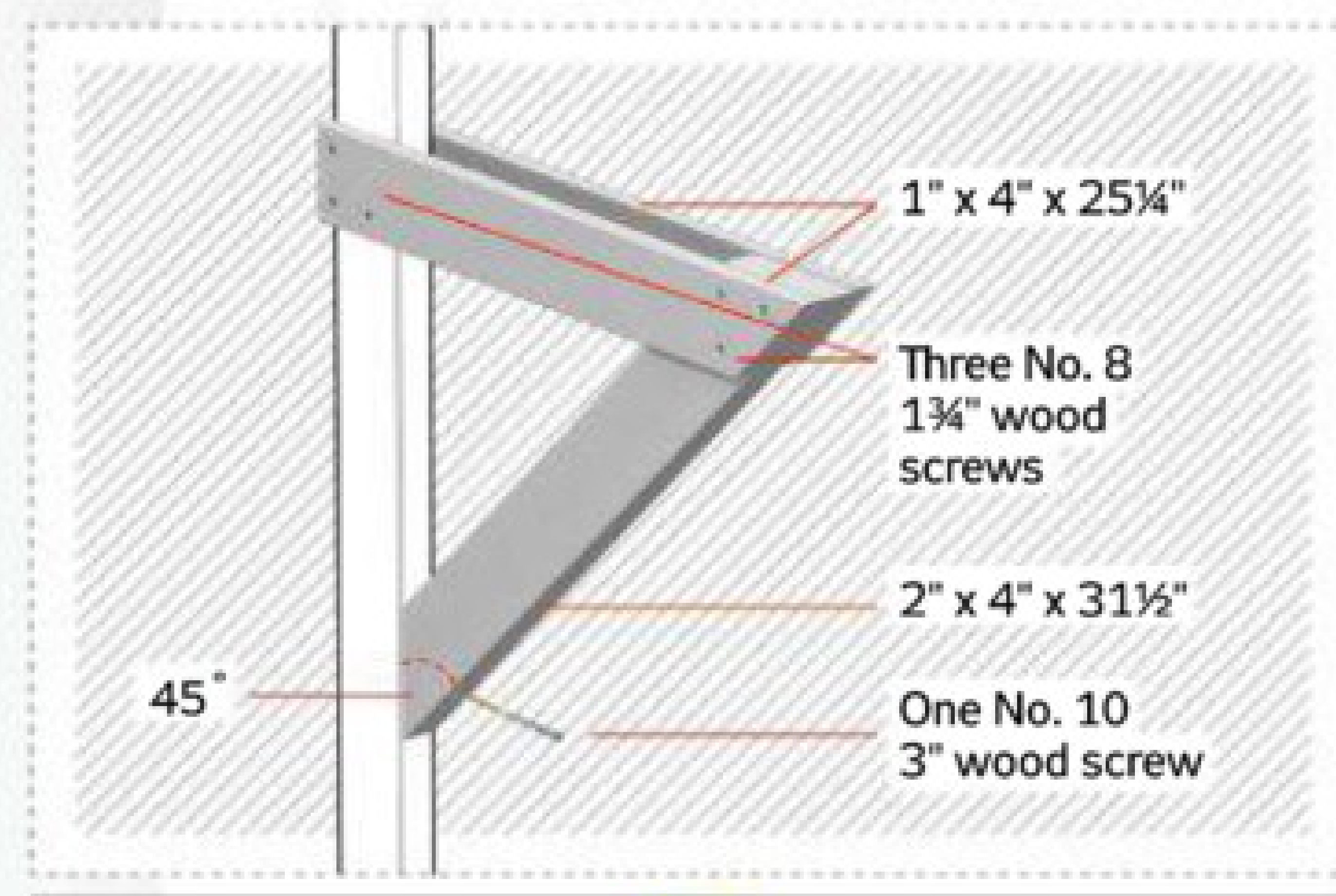
There's a reason home ownership is called the American Dream. Owning a home has long-standing support in this country because home ownership benefits individuals and families, strengthens our communities, and is integral to our nation's economy.

To learn more about the benefits of home ownership, visit www.REALTOR.org/topics/homeownership/materials_you_can_use

Homeowners Clinic

by Roy Berendsohn

Q+A



A When I arrived recently at PM contributor Joe Truini's place, I was amazed to find that along with everything else he had resting on his shop shelves, he had placed the concrete blocks we were about to use to test a big bunch of hammer drills. The shelves looked no worse for the load, so I took a good look at their supports and remarked on how simple they were. "Shelves don't have to be complicated to work well," Joe said. "Just the opposite is true. The simpler and sturdier you build them, the better they are and the more of them you can build." That's his design in the photo to the left.

There are several merits to Joe's brackets. First, they are so strong that they can function as workbench supports or hold up a sturdy shelf. Second, almost anybody can build them using the simplest of tools. If you have advanced skills, you can take Joe's design and scale it up using heavier and wider lumber. As far as the shelf across the supports is concerned, you can use anything from 3/4-inch plywood to 2x lumber. The closer you place the supports to each other (at every stud versus every other stud or at intervals that are farther apart), the less likely the shelf is to sag.

The metal shelves in your garage might be worth salvaging. Bring them back into square and brace them by screwing plywood to their backs. Fasten



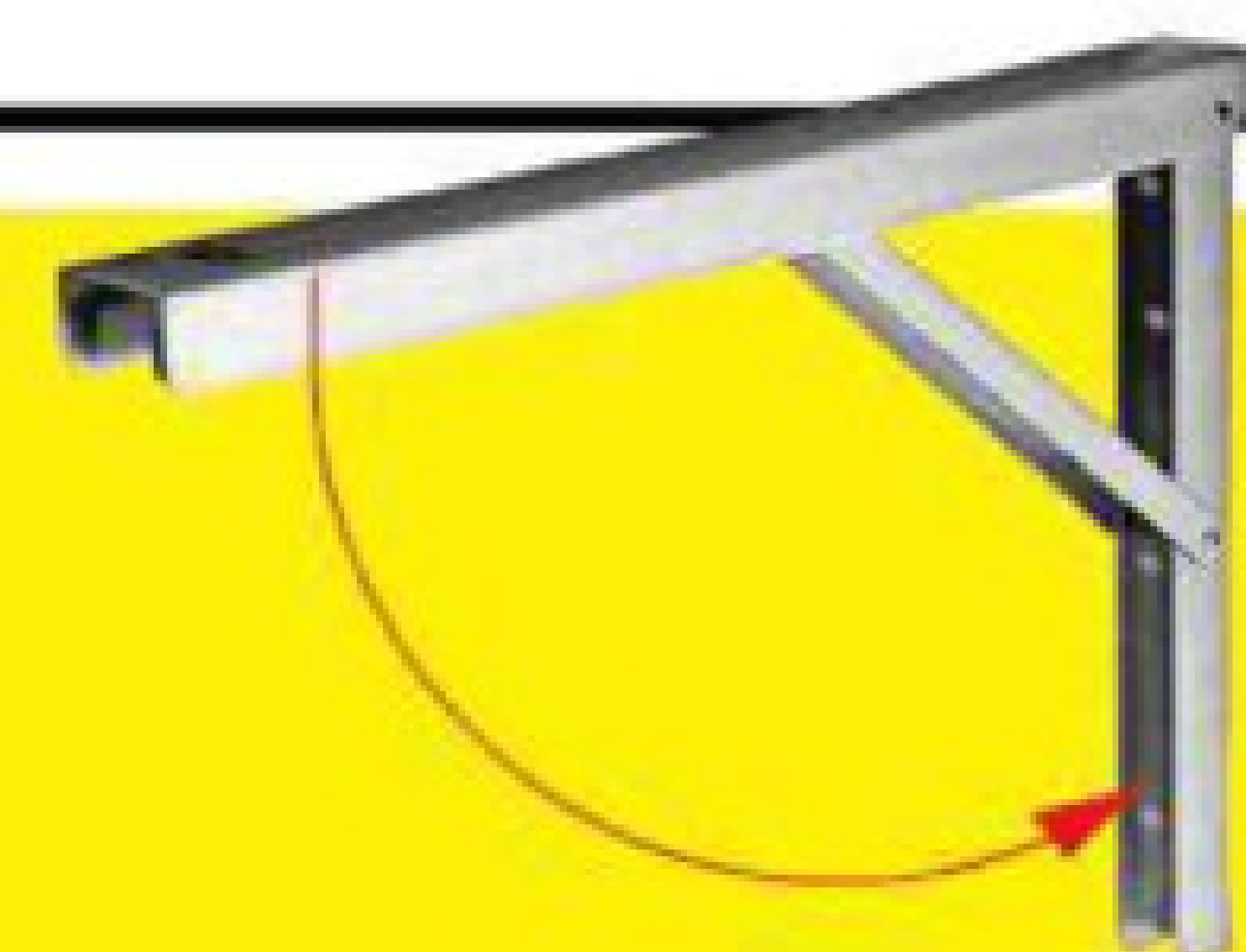
Shelf Life

When we moved into our house several years ago, one of the first things I did was remove all the sagging shelves that were used for books and basement storage. I

left up some metal shelves in the garage, but they lean in all directions. Now I want to do things right and build some bullet-proof, heavy-duty, last-forever shelving. Where do I start?

Fold-Down Shelving

You can never have too much shelving; then again, there are times when it can get in the way, as useful as it is. Enter these heavy-duty shelf brackets from Rockler (about \$23 each). A pair fastened to wall studs at 16 inches on center is rated to support 750 pounds. When you need more space and less shelving, activate their spring-loaded mechanism and fold them down, out of the way.



PHOTOGRAPHS BY DEVON JARVIS

ILLUSTRATION BY GEORGE RETSECK

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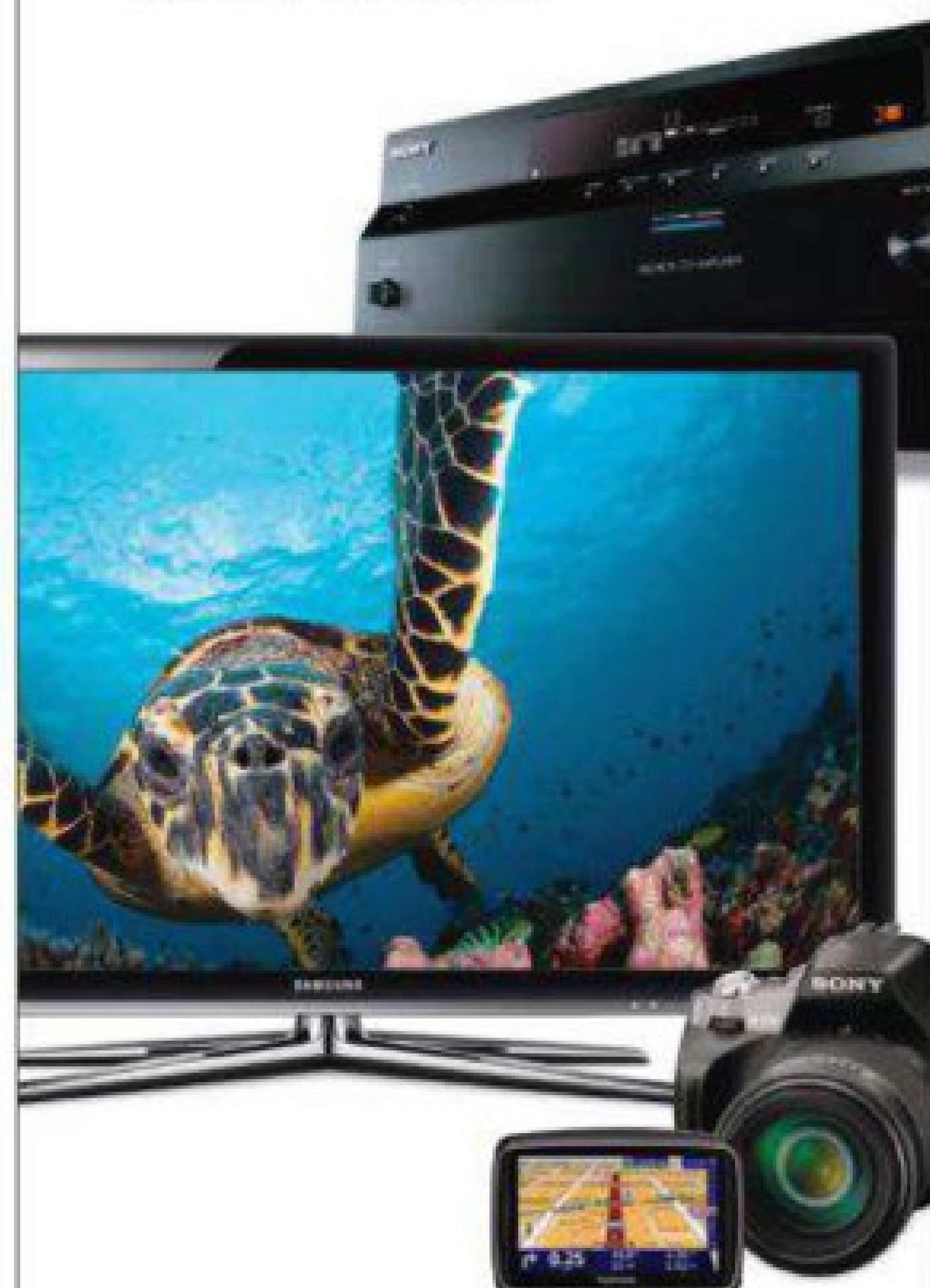
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DIY **Home** HOMEOWNERS CLINIC Q+A

the panels with sheet-metal screws that penetrate as deep as possible into the plywood. Given that plywood is strongest in the panel's long axis (in the direction of the face grain), you should orient that axis vertically.

For any readers who are already sitting down to fire off an email in support of wood screws or drywall screws for bracing metal shelves, a study by the Engineered Wood Association (formerly the American Plywood Association) has settled the question. The organization tested wood screws against sheet-metal screws for fastening sheet metal and plywood (apawood.org; search under Publications for Technical Note E830D). The result: Sheet-metal screws rule. Their full-thread shank engages the metal, while the unthreaded shank below the head of a wood screw does not.

Lighten the Load ➔ I'm restocking my toolbox. My sons are going to get the tools I started with, and I'm going to buy everything new. This time, I want tools that weigh less. What should I look for?

This is the era of lightweight tools. There are hammers with titanium heads (stiletto tools.com) and aluminum box-beam levels (johnsonlevel.com)—and even the wrist-straining cast-iron pipe wrench can be had in an aluminum version (ridgid.com). To restock your box, look for types of tools that have replaced steel parts with magnesium, aluminum or plastic. Even where you can't reduce the weight of a tool, good industrial design can make it easier and less tiring to use. Whenever possible, handle several variations of a tool before you buy one.

Cold Shower ➔ Can you help us with a problem with our water heater? It delivers plenty of hot water in the morning, when my husband takes a shower. In the evening, when I use the same shower, it produces only lukewarm water. I don't use hot water before taking a shower, so I'm stumped by the problem. The water heater is natural-gas-fired, if that makes a difference.

My first thought was that there's gas-pressure trouble in the evening, so I ran that theory by Kenny Hart, a second-generation master plumber in Virginia Beach, Va. He's more than a plumber—he's a home inspector and a plumbing detective, you might say.

"A gas-pressure problem that occurs only in the evening is possible but unlikely," Hart says, pointing out that this would also make itself known at other gas appliances, such as a kitchen range or heating equipment.

He says that if the water heater's temperature is properly adjusted and it works well in the morning, the problem probably doesn't lie with the appliance either. The remaining suspect: the distribution system. "One of the first things I look for is a problem with a hot-water recirculating pump," he says.

The pump cycles water through the water heater to ensure that hot water is instantly available at sinks and showers. If the recirculating pump is on a timer and that's switched off in the evening, there's your answer. Reset the timer and you've got it made. Also, a simple plumbing mistake or a failed component (such as a check valve) would allow hot and cold water to mix when the pump is off.

"Since modern plumbing systems moved beyond hot on the left and cold on the right, they've become more problematic," Hart says. When you add in modern conveniences like recirculation systems and devices that protect against scalding, back flow and thermal expansion, "you need to add pages to your troubleshooting book."



Got a home-maintenance or repair problem?

Ask **Roy** about it. Send your questions to pmhomeclinic@hearst.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

Assorted Nuts 🟡 I was assembling a piece of knockdown furniture and noticed the kit contained nuts with built-in washers. Because I find these to be convenient, I went to buy some for another project, but my local hardware store doesn't stock them. In any case, they said they'd never heard of them. What are these nuts called, and where can I find them? Nuts with an attached lockwasher are called Keps nuts. When the washer and nut are one piece, that's a flange nut. You can find both at hardware or fastener suppliers on the Web. I'm surprised your hardware store is not familiar with these nuts. Maybe while you're looking for these fasteners, you should also look for a different hardware store.

Sagging Crown 🟡 I installed MDF crown molding in a number of rooms, and some of the corner joints and splices have come apart and cracked. I've tried nonshrink filler to patch the problem areas, but it comes loose. What causes this, and what's the solution?

There are two likely culprits. One is roof-truss uplift, and the other is improper nailing of the MDF (medium-density fiberboard) molding.

The bottom chord of a roof truss (the part of the truss immediately above the ceiling) can sometimes bow upward in the winter. That's caused by the difference in temperature and humidity where the bottom chord is relative to the rest of the roof truss. That chord is buried in insulation and stays comparatively warm and dry; the upper truss chords are exposed to cool and damp air moving through the attic. These chords swell and elongate slightly, causing the truss to bow and cracking the drywall joint at the corner where the wall meets the ceiling.

Anytime that there's truss uplift, expect trouble in the molding that bridges the wall-ceiling joint, especially in the direction parallel with the roof trusses (the direction the ceiling bows). I don't know of a good solution other

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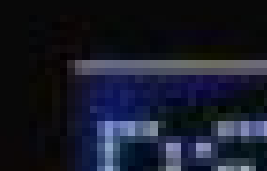
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than removing the crown molding.

But let's hope that's not the problem, and it's just a matter of inadequate nailing. Weighing 40 to 50 pounds per cubic foot, MDF is much heavier than the two most common woods used in crown molding: white pine (26 pounds) and poplar (about 31 pounds). Even red oak (40 pounds) is only barely in its class. The heavier the material, the more firmly it needs to be nailed. Use a finish nail $2\frac{1}{2}$ to 3 inches long.

But as they say on those TV gadget commercials, "Wait, there's more." If you live in a humid environment, any wood trim (especially wide and thick wood trim) will expand as it takes on moisture, and shrink as it gives off moisture. Properly nailing it is the only way to keep it from working itself loose. In one axis of the room, you'll have both studs and joists (or chords) to fasten to, but in the other axis, you have only the studs. The

remedy is to screw a plywood backer board along the entire wall-ceiling perimeter. That provides a sound nailing surface anywhere in the room. To learn more, visit popularmechanics.com and have a look at Pro Tips for Installing Crown Molding.

Lights Out ☺ I'm at my wits' end. We live in a 2-year-old home with three circuits protected by AFCI breakers that seem to trip at random. I can't have my 74-year-old mother stumbling around in the dark every time these things trip. The electrician who wired the house has been out three or four times to replace circuit breakers and to test for electrical leakage. He can't find anything wrong. Ideas?

AFCI circuit breakers—the abbreviation stands for Arc-Fault Circuit Interrupter—are still a relatively new technology, and a troublesome one, in the view of many electricians and homeowners. Not so, counter AFCI manufacturers and electrical inspectors. They say these devices save lives by protecting against fires.

AFCIs are circuit breakers that cut power when they detect the electrical signal given off from an arc (a spark) caused by a faulty electrical connection or a damaged wire. They entered into the National Electrical Code in 1999, and several revisions to that code have increased the places in a new home where they must be installed.

Shortly after AFCIs were introduced, homeowners began reporting that appliances such as vacuum cleaners could cause them to trip. In other cases, the AFCIs tripped when there was no apparent activity on the circuit. "Sometimes the problem is extremely subtle," says Joe Cristino, P.E., an electrical engineer in Tolland, Conn., who investigates electrical failures. "Even a remote control for a ceiling fan or a variable-speed frequency control on the fan motor can set up a harmonic in the house's wiring that the AFCI interprets as a fault condition, causing it to trip."

The good news is that new AFCI breakers are better able to distinguish between normal electrical use and a genuine problem. Furthermore, investigations into repeated tripping of AFCIs usually reveal faulty electrical components, bad installation or damaged wire. In other words, the AFCI has done its job and prevented a fire.

Since your electrician has replaced the circuit breakers, it's unlikely that the AFCIs are to blame. The problem could be anything from a drywall screw or a nail touching a wire to a poorly installed switch or outlet to a defective ceiling light or appliance.

What can you and your electrician do to get to the bottom of this? First, search for "Wiring Practices & Troubleshooting with AFCIs," a white paper published by the National Electrical Manufacturers Association. Also, given how difficult it is to find the source, electrical equipment manufacturer Siemens has developed a tool that speeds the troubleshooting process. It's called the Intelli-Arc Diagnostic Tool, and it's a \$369 device that is wired into the service panel to identify and measure



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hardware stores and home centers
Manufacturer: Eazypower

NO, SKIP IT:

Carbide isn't necessary if you countersink a handful of screws a year, especially in softwood. A single countersink cutting surface is adequate, though slower.

the electrical characteristics of a circuit. Yes, it's expensive. On the other hand, paying up is better than living in a darkened house.

Cast in Stone ☺ I want to make a cast-concrete planter for the backyard.

What would be better, regular concrete mix or countertop mix?

Either product will work. However, the countertop mix will flow into the form more readily, thanks to an additive called superplasticizer. This chemical reduces the viscosity of the concrete without increasing the water content. Adding extra water to make concrete more fluid weakens it, and you should avoid the practice both when casting concrete and when doing standard concrete work, such as making sidewalks. Another benefit of superplasticizer is that it reduces or eliminates the small holes left in the concrete after it's been cast. In the precast-concrete business, these are known as

bug holes, and they are the last things you want to find after you've gone through the trouble of casting something in concrete and then stripped the forms.

There is a cost premium for countertop mix: An 80-pound bag costs \$10 to \$11, while standard concrete costs \$3 to \$5. But this isn't a large project, so the total cost of materials is not going to be very high.

Both types of concrete are more than strong enough. Quikrete's countertop mix will cure to 6000-psi strength after 28 days; the standard mix cures to 4000 psi.

Remember to include a form for a drain hole. Otherwise, the planter is liable to hold water. Excess water contributes to root rot, and it can crack the planter during the winter, when water sitting in its base freezes and expands. The form for the drain hole need not be anything more elaborate than a well-oiled piece of wood dowel rod.

PM

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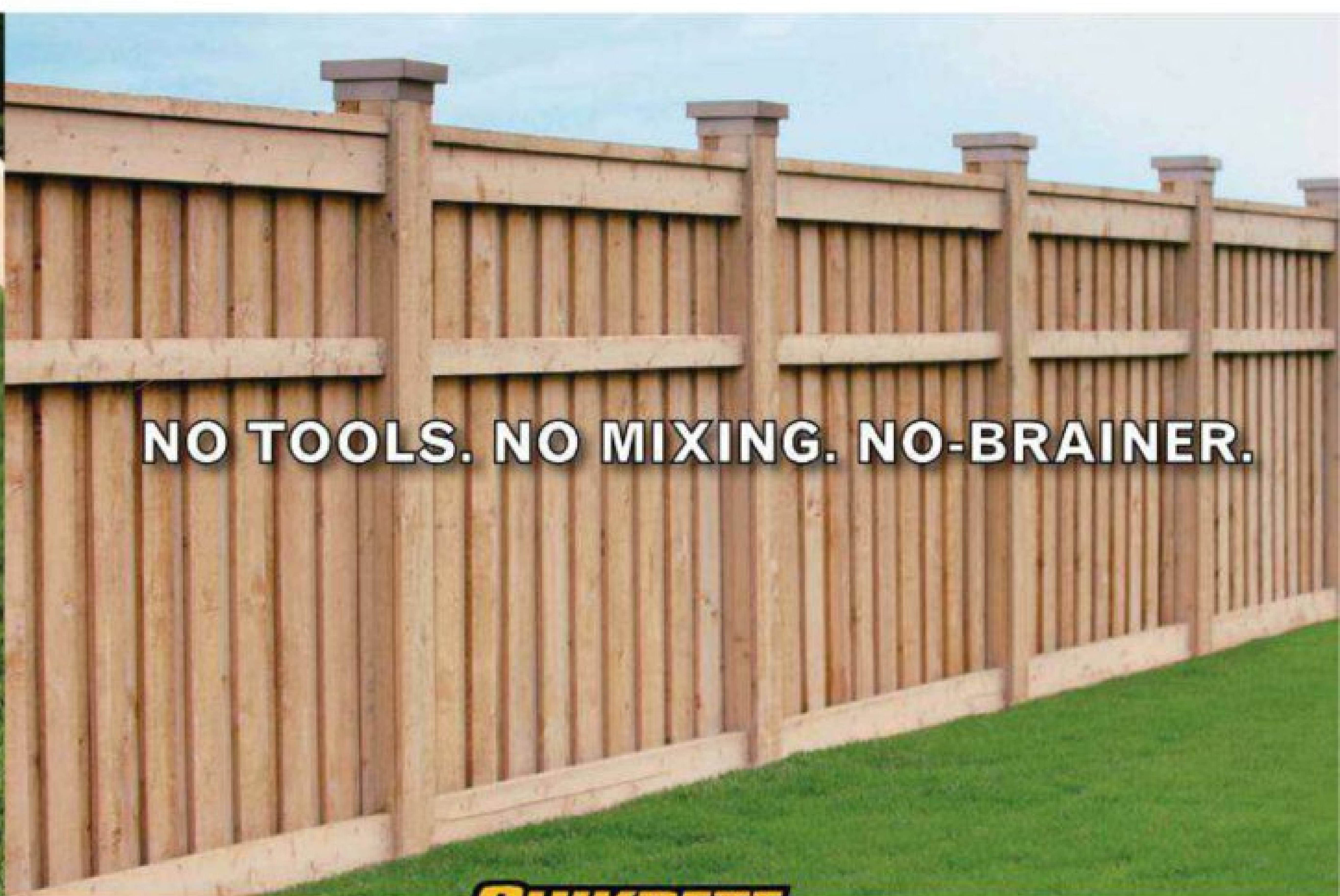
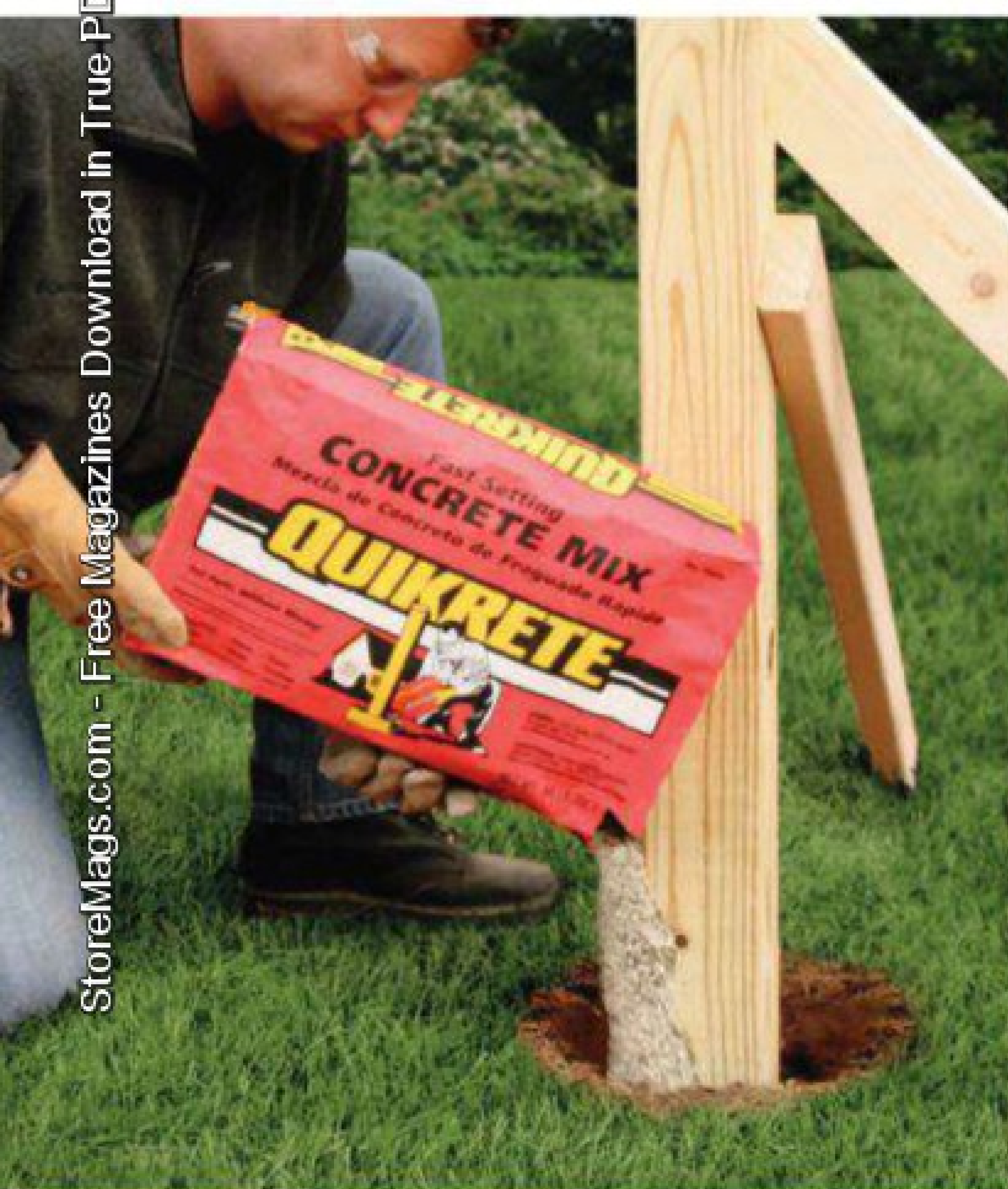
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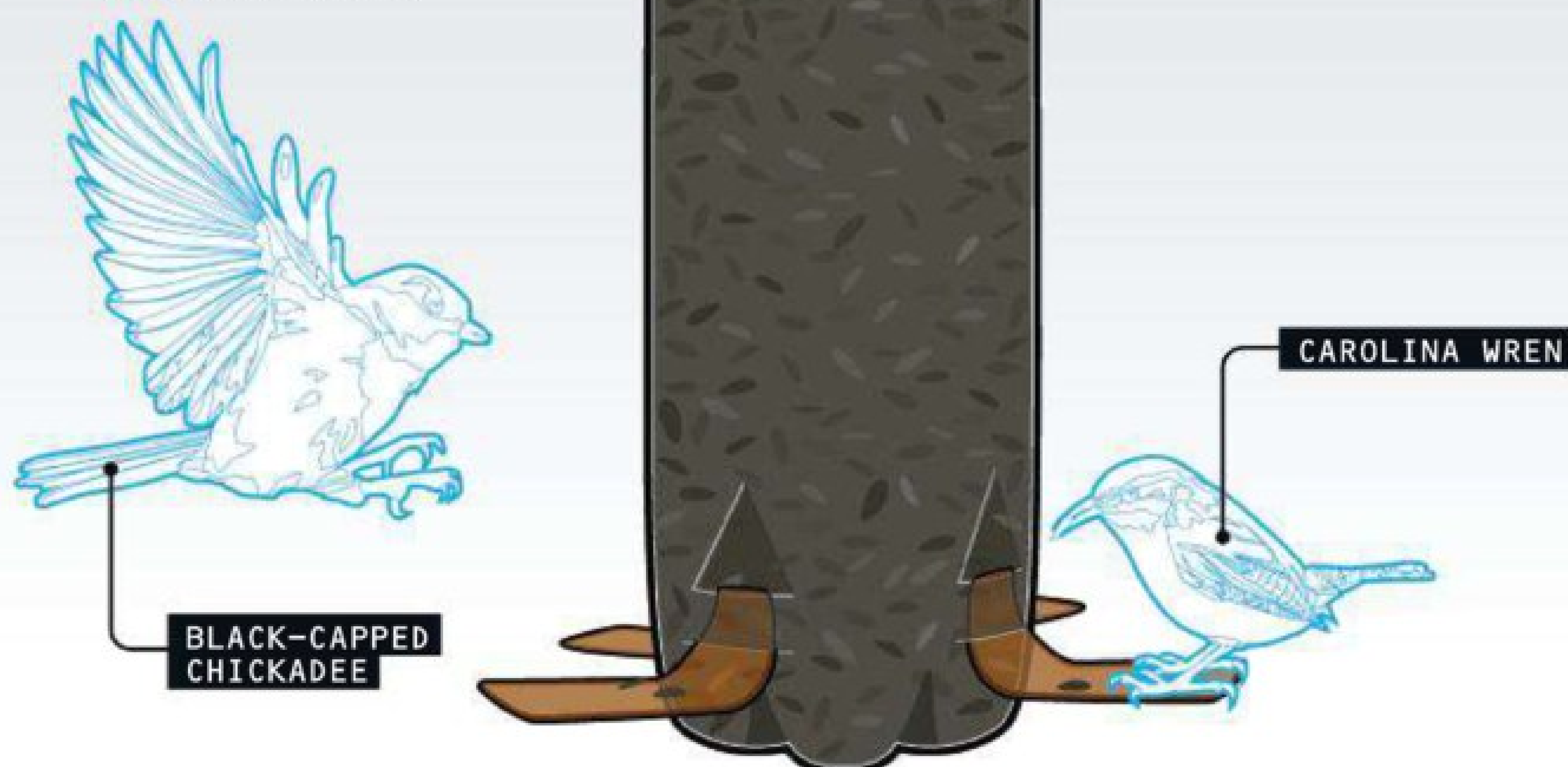
PM
Saturday

ONE-DAY PROJECT

Squirrel-Proof Bird Feeder

MAKE FINE-FEATHERED FRIENDS AND GIVE RODENTS THE RUNAROUND WITH A SEED JUG ON A SPINNING TIGHTROPE.

BY JOSEPH TRUINI



16 TO 25 FEET
BETWEEN TREES

Location:
Roxbury, Conn.
Food: Black-oil
sunflower seeds
Cost: \$17.67
Squirrel Menace:
Neutralized

1 → GATHER THE GEAR My bird feeders lure Carolina wrens and tufted titmice—but I can't stand to see rodents raid the seeds. So I devised a fortified feeder. Hang a modified 2-liter soda bottle between two trees spaced 16 to 25 feet apart, using 16-gauge galvanized-steel wire, two 2-inch No. 6 screw eyes and one $\frac{1}{4}$ x 2-inch eyebolt with nuts. Ten 1-foot lengths of $\frac{1}{2}$ -inch PVC spin on the wire, stopping squirrels as birds perch on pieces of a 20-ounce bottle.

2 → CUT A JUG At 1½ inches above the

2-liter-jug bottom, use a utility knife to cut the seed ports: four triangles with $\frac{3}{4}$ -inch sides. Cut a $\frac{3}{4}$ -inch-long horizontal slit $\frac{1}{2}$ inch below each port. Use snips to cut $\frac{3}{4}$ x 3-inch L-shaped strips from a 20-ounce bottle bottom. Fit the strips in the slits, concave side up. Drill a few $\frac{3}{16}$ -inch drainage holes in the 2-liter jug bottom.

3 → HANG IT UP Twist a screw eye into both trees 8 feet from the ground, then thread the wire through one eye. Wrap the wire around itself about 10 times to secure it.

Fit the 10 lengths of pipe over the wire, pull it taut to the second screw eye, then wrap it tightly. Drill a hole through the 2-liter jug cap and attach the eyebolt with two nuts. Hang a short length of wire from the horizontal wire midway between the pipes, then tie that length to the eyebolt, twisting the wire around itself to make the connections. Pour seeds through a funnel to fill the jug.

4 → BIRD-WATCH Birds love it. Squirrels either stay at the tree or spin off the pipes. They dive but can't grip the bottle. Suckers!

+ MORE TO DO IN AUGUST

Fish the Smokies

→ Offering fly-fishing lessons, casting classes and hands-on gutting demos, the Talking Trees Children's Trout Derby teaches kids the art of angling Aug. 5 to 6 on the Oconaluftee River in Cherokee, N.C.

Save a Screen

→ A damaged window screen lets in skeeters for a feast, but a dab of clear nail polish can plug a tiny tear. For bigger rips, trim the torn edges, cut a matching screen patch and seal the seam with clear silicone caulk.

Gather Some Steam

→ Celebrate old engines at the 48th Badger Steam and Gas Engine Show, an annual tractor parade, swap meet and seminar where kids drill, tap and build a working model engine. Aug. 19 to 21, Baraboo, Wis.

Build with Bales

→ Straw-building experts Tom and Satomi Lander open a Kingston, N.M., workshop to bale-construction fans for two days of stacking, sewing, pinning and piling. Aug. 27 to 28; visit landerland.com.

Blast Stinkin' Trash

→ Freshen up empty outdoor garbage cans using a detergent blend shot from a 1000-psi pressure washer with a 40-degree nozzle, pro washer Jon Hoch says. Soak 2 minutes, empty, then spray the bottom.

The Wrong Haul

(CONTINUED FROM PAGE 63)

heavy weights. "Making something real out of someone's vision," he says, "that's where the fun is."

Knight worked on the design team for the Eliminator, and he is helping Brown on the squid trawl project—a partnership between Knight, Brown, his fishing partner Steve Arnold and the Rhode Island Sea Grant organization. It has involved not only tests in the open sea, but hours of computer-aided design. The team even made a trip to Canada to run a scale model of the squid trawl through a 72-foot-long flume tank at the Fisheries and Marine Institute of Memorial University of Newfoundland. Watching in real time, the trawl designers could see how various haul speeds affected the experimental net's elongated funnel.

"Whatever solutions we come up with have to work out on the water," says David Beutel, aquaculture coordinator at the Rhode Island Coastal Resources Management Council. "For fishermen, there is a growing environmental-stewardship aspect to this work. But it's still driven by their need for efficiency. You make the most money when you are most efficient."

Such resourcefulness requires change. In fact, this is the last voyage for the *Grandville Davis*, a mahogany-hulled work boat Brown built 32 years ago. He has bought a new fiberglass boat whose light weight and shrouded propeller can tease out efficiencies for a more modern way of fishing. After more than a quarter-century of the *Davis* catching as much as possible, its last hurrah is helping the global fishing industry move toward a sustainable future.

"Every dollar I've ever made in my life, I've made on this boat," Brown says, working the levers that drop the trawl for another experimental tow. "I'll miss her, but things are changing. Society's willingness to support commercial fishing is directly correlated to our ability to prove that we can take care of a national resource. That was not a part of our language five years ago." **PM**

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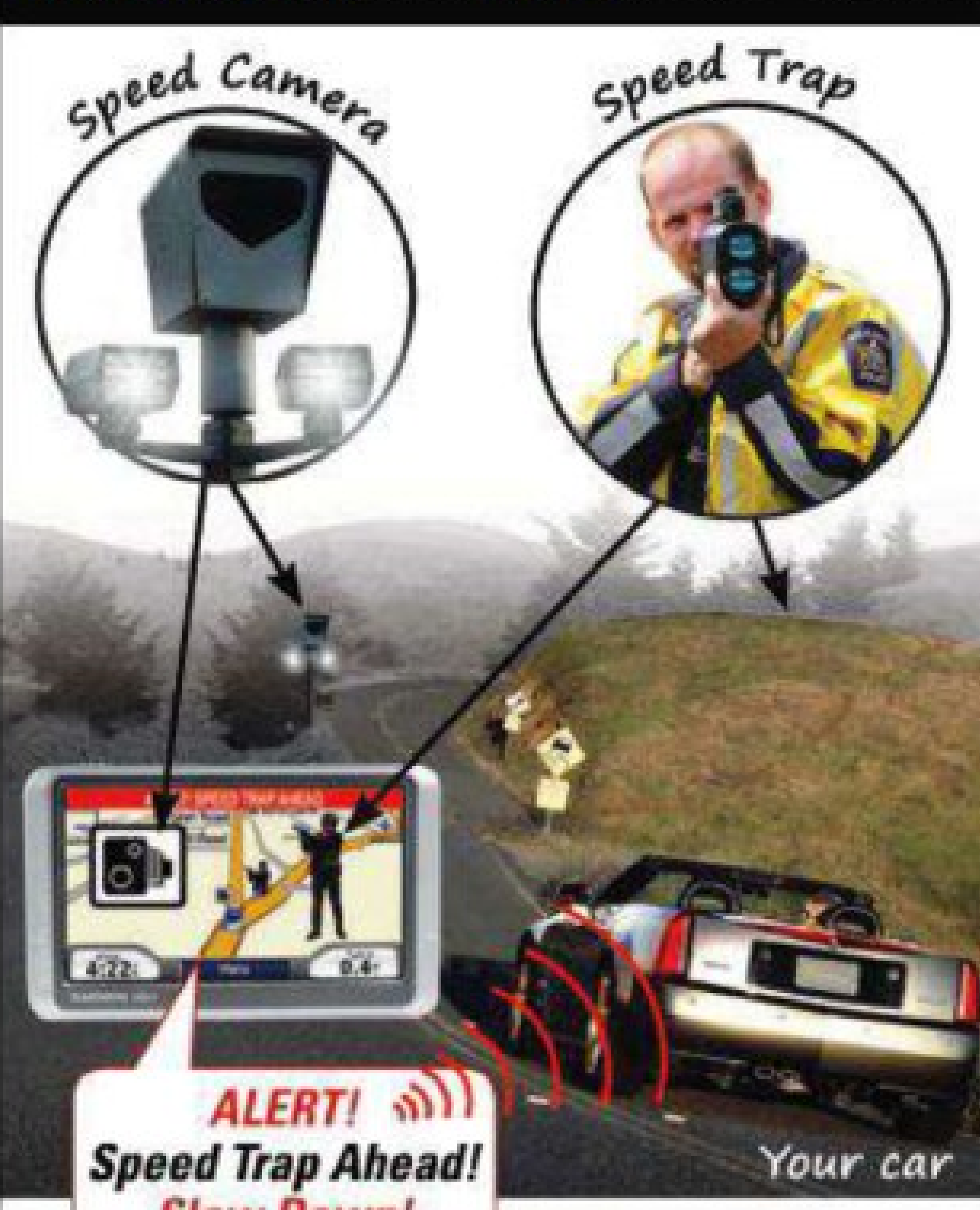
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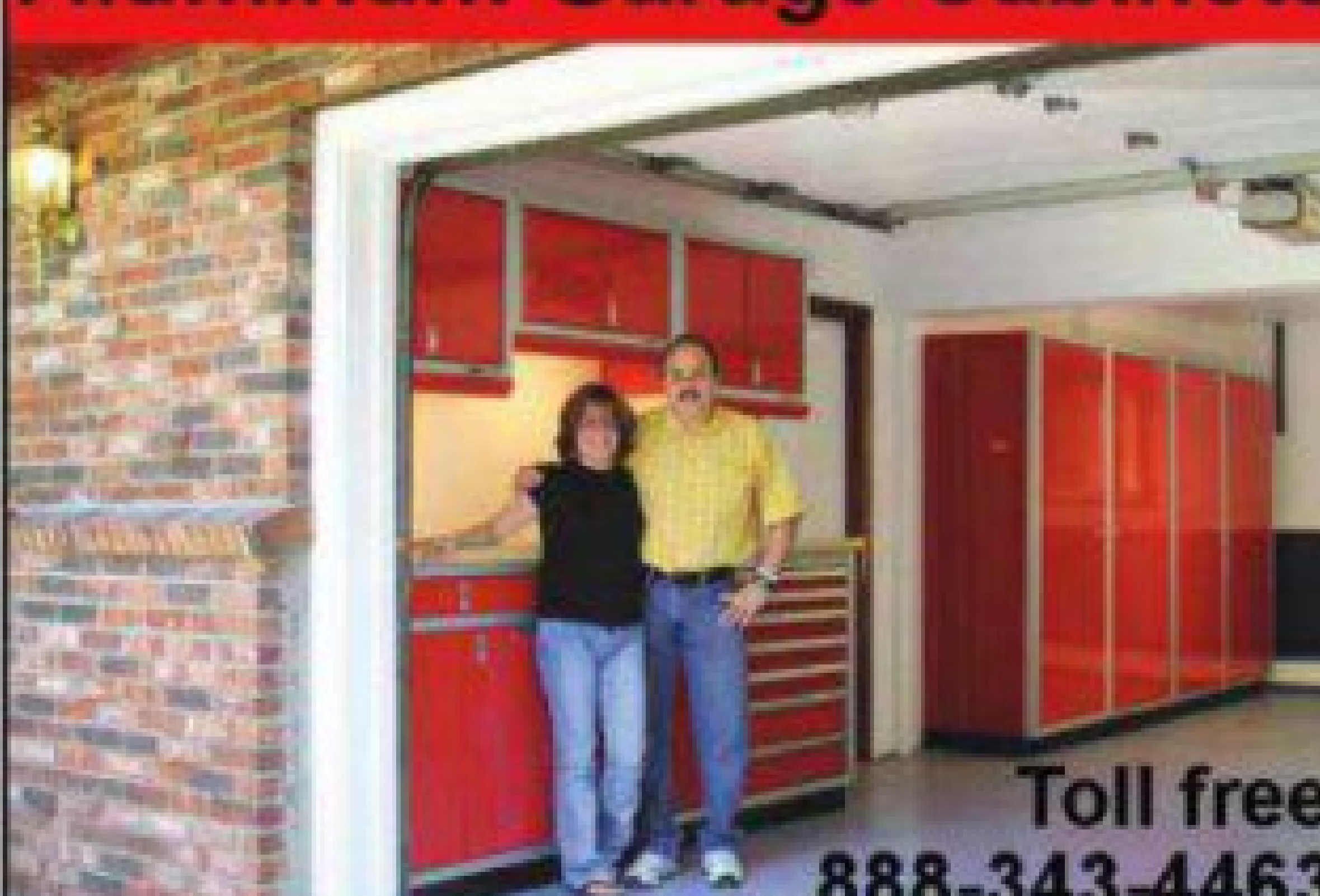
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Name: MATT EADY
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✕ **When Matt Eady fell in love** with the guitar in high school, it seemed only natural to him that he learn how to build it. After completing a one-year master luthier program, in which he learned to make hollow- and solid-body guitars, Eady took a job at the Gibson Custom Shop in Nashville, Tenn. There, he helped repair up to 70 guitars a day, including Dickey Betts's 1958 Les Paul. Then, as head finisher for Benedetto Guitars, Eady applied lacquer to make the grain come to life. "Finishing makes or breaks your instrument," he says. "It's my favorite part." This year, Eady opened his own shop, focusing on finishing and repair, but he plans to one day build signature guitars. "There's an instant bond between you and the musicians you're building for," he says. "Not to mention it's cool as hell to play an instrument you've made." — AMBER ANGELLE



GUITAR BUILDING 101

MATERIALS

→ The sound of the guitar is influenced by the wood used for the body. Mahogany creates rich, warm tones; cedar yields mellow ones. The neck must be able to withstand string tension, so Eady uses harder woods like maple.

CONSTRUCTION

→ Eady employs a band saw to cut out the shape and design of the guitar, and a router to carve the electronics and pickup cavities and the area

where the neck attaches to the body. He starts with a 20 x 9-inch board, which he mills, squares and saws down the middle. When the pieces are glued together, forming the guitar top, the grain is a mirror image of itself. "It looks more attractive, and the guitar ages better," Eady says. The top is glued to a mahogany body. Next, he cuts the neck profile out of a square piece of wood

and joints the face of the neck where the fingerboard will be glued. "You use that fingerboard as a template to rout out the neck shape," Eady says. Then he adds frets.

FINISHING

→ After he glues the neck to the body, Eady sands the guitar and applies color

(pigmented lacquer) or toner (translucent, colored lacquer) using an HVLP (high-volume, low-pressure) spray system. He then sprays it with a clear coat of nitrocellulose lacquer and buffs it to a high gloss.

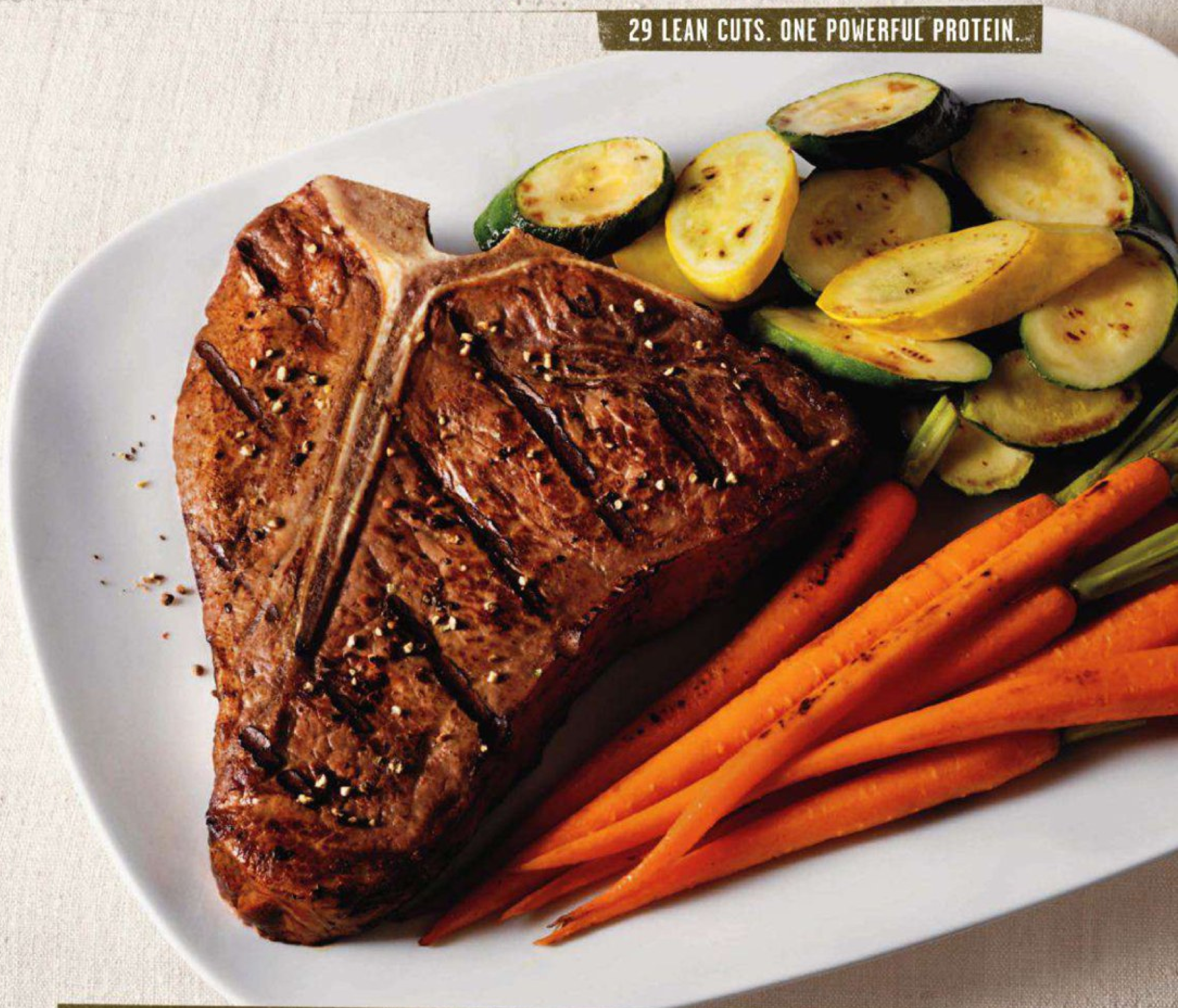
ELECTRONICS

→ Next, Eady inserts the tuning machines, volume and tone controls and bridge, and installs the pickup. After he adjusts string and nut height and neck relief, "it's ready to rock," he says.

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